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The Outlook.

Never before in the history of this journal has the New Year opened with such satisfactory promises of prosperity. The past year has been one of great commercial activity, due to the reaction from a period of conservatism which tied up capital for a time and to the very profitable harvests in 1904. The same conditions remain in force to-day. In spite of the crude sensationalism of cheap magazines, which print attacks as untrue as they are uncalled for on established business enterprises, and in the face of marked fluctuations in the stock market, which have been engineered by those whose object is merely to trim the sails of aspirants for reputations as skillful "operators," the people of the country at large have remained unmoved.

The chief reason for anticipating a continuation of present conditions is the conservatism of the people generally. With the accumulation of money there always comes the strongest test of character. It is not hard, in fact it is enjoyable, to face and overcome business obstacles, but the wiles of the promoter are much more difficult to detect and avoid. The "good things" that are brought out in times of prosperity as bait by which the savings of one man can be transferred to the pockets of another have been many of late, but they have fallen very flat. Although people have accounts in the savings banks they have not shown any special eagerness to purchase gold bricks, and have remained deaf to the blandishments of the financial bunco man. The sudden rush of heavy orders that came a year ago has not resulted in frantic endeavors to enlarge manufacturing establishments. Those companies which had previously laid plans for new works have gone ahead with their construction, others have made moderate enlargements, and there are others who have perfected plans for new manufacturing facilities. But there has been none of the speculative building which does so much harm to the industrial prosperity of the country, and none to speak of seems to be contemplated. Affairs have passed into the control of better men than formerly. The man who thinks that good management means spending money "pushing" business where there is no business to be secured has been sidetracked to give way to the man who is not a plunger. Corporations are making more money by saving needless expenses; the order has gone out in many works that absolutely no expenses shall be incurred that are not really necessary and as a result great savings in salaries and other lines have been effected. Everywhere the same spirit of justness toward employes is to be seen; good wages to good men, and no place at any wage to poor men or the disturbers of harmony. The railroads have had the courage to stop the pass-giving habit and there are good grounds for believing that publishers will soon abolish the commission-giving habit to advertising agents, so that before long the enormous sums spent by them will be handled on the only basis that will yield the best returns.

Shearing Stresses.

The important part played by shearing stresses in many portions of engineering structures and the need for more investigations concerning their character and value have been frequently mentioned in this journal. The results of such investigations would throw much light upon some questions of design which are of much more weight than was supposed in the early days of structural engineering. If properly conducted they would not only yield practical data of distinct value, but they would also aid much in determining the real character of shearing stresses, which are not at present any too well understood.

The scarcity of this class of data is so pronounced as to be the subject of comment in many of the standard works on the resistance of materials. It is therefore a matter of some interest to note a short paper presented by Mr. E. G. Izod to the Institution of Mechanical Engineers of Great Britain, in which he records the results of a number of shearing tests on a considerable variety of materials conducted with the particular object of eliminating all other stresses except shear, as far as possible, in the fractured test specimen. As the capacity of the testing machine was 100,000 lb. only, the test specimens were not large, but the results show clearly many characteristic features. The materials tested included cast iron, various grades of steel, wrought iron, bronzes and similar metals, and wood. It is not necessary to consider the details of the ultimate resistances found further than to observe that they harmonize with the results obtained by other experimenters, so far as corresponding tests have been made, except that the ultimate shears of Mr. Izod's cast iron specimens appear to be distinctly higher than are usually taken for that metal. It has not been uncommon to consider the ultimate shear and ultimate tensile resistance of ordinary cast iron as practically the same, whereas these tests make the ultimate shear from ten to about fifty per cent. higher than the ultimate tensile resistance. The physical characteristics, however, of cast iron are so irregular that such an apparent anomaly calls for no special explanation.

The part played by the shearing resistance of concrete in the modern extension of reinforced concrete construction as well as that of other masonry, has come to be a matter of constant comment in the literature of that branch of engineering work, and the ultimate shearing resistance of structural metals and timber plays an equally important part in the carrying capacity of members of those materials. The influence of shearing stress upon the design of the webs of plate girders has long been recognized in a more or less imperfect way, and certain provisions, largely arbitrary, are introduced in many specifications in response to that recognition. There are few instances in which that feature of design is rationally treated, largely because shearing action is so little understood. Indeed, it is difficult to state just what a shearing action is. For all ordinary purposes, at least, we dispose of tension and compression as if the corresponding stresses were easily and clearly understood, one producing separation of the molecules of the material and the other forcing them together. If the attempt be made along the same lines to account for shearing stresses difficulties are at once encountered.

A quite ordinary statement regarding the character of a shearing stress is to the effect that such a stress, within the elastic limit, causes the molecules to slide over each other without increasing or separating their mutual distances, but in a continuous solid mass such an explanation will not hold, except possibly for indefinitely small motions. Any sensible movement of one indefinitely small portion of a solid material over its neighbor will bring it nearer to others and separate it farther from those in the opposite direction. The result discloses the practical impossibility of producing a shearing stress without inducing tension or compression or both in the same location where shear only is assumed. This accounts undoubtedly for the shape or condition in which a fracture by shear leaves the ruptured parts of the test specimens. In addition to this consideration, the theory of stresses in solid bodies shows that no one stress can exist by itself. If a test piece is subjected to pure tension there will be shear of some finite intensity on every plane in the piece except those which are at right angles to the direction of the applied force or parallel with it, and the same observation holds for compression.

In the ordinary structural member, shear is accompanied by both tension and compression, the planes on which their greatest intensities occur being at right angles to each other and at 45 deg. with the planes of greatest shear. This latter fact explains at once the reason for the buckling waves in the web of a plate girder being at angles of 45 deg. with the neutral surface of the beam at and in the vicinity of that surface. The fact that these directions change as the neutral surface is departed from is not generally recognized nor the additional simple fact that the field of greatest shear is in the vicinity of the neutral surface, while the intensity decreases as the upper and lower flange surfaces are approached and disappears when they are reached.

It has long been recognized in material like timber, where the resistance to longitudinal shear along the fibers is low, that failure is produced by the shear in the neutral surface and not by the tearing or crushing of the fibers. A somewhat similar result may take place in the case of reinforced concrete steel beams. At the present time reliable values of ultimate shear along the fibers of timber and in concrete masonry are practically unavailable. Some tests have been made, so that more or less crude values of those physical quantities may be taken, but comprehensive and reliable investigations productive of reasonably accurate data of this character have not yet been undertaken.

This whole field of the effects of shearing stresses upon structural materials is but little explored, although the values of physical data, both within and above the elastic limit, are urgently needed for the proper design of many structural members. In such investigations it is absolutely essential that the condition of the material subjected to shear be given its full weight in the ultimate results. If a test specimen is put into such a shearing machine as that used by Mr. Izod and others, the conditions cannot fail to be somewhat different from the shearing which takes place in the metal at the neutral surface of a bent beam. It is quite possible that below the elastic limit this observation may not hold, but it certainly will hold in connection with ultimate shearing resistance. No engineer with suitable apparatus available to him can render a greater service to the field of structural work than by prosecuting investigations in the shearing phenomena of material as it is actually stressed in engineering structures.

The Usefulness of Minor Engineering Societies.

The great engineering societies, such as the American Society of Civil Engineers, the American Society of Mechanical Engineers, the American Institute of Electrical Engineers, and the American Institute of Mining Engineers, are manifestly admirable organizations. One of the avowed reasons for their existence is the promotion of social and professional intercourse among the men who compose them. This intercourse is more essential to the young man, who has yet to make a name for himself and who has so much to learn from others, than it is to the older engineer of established reputation and well-rounded attainments. The full privileges of these societies can only be enjoyed by the engineers of the latter class, for such alone are eligible for full membership. It is desirable and proper that this should be as it is, and that the requirements for admission to the highest grade in the national engineering societies should be kept as high as may be reasonably possible. An engineer should be, and usually is, proud to be able to write after his name, whenever modesty and good taste may sanction it, the letters which show that he is a member of one of these learned societies.

It is true that each of these societies offers lower grades of membership, with slightly curtailed privileges, to which the young engineer may be eligible, but there are several reasons why many young men are deterred from making application for admission to them. One of these is that some men cannot easily overcome the feeling of false pride which makes them loath to accept any but the highest grade of membership. Such men feel that their classification as Junior or Associate Member publishes to the world the fact that they are not entitled to the higher grade, and they prefer not to make application for admission until they can feel reasonably sure of being admitted to the coveted seats of the mighty.

Again, the cost of admission fees and dues for any grade of membership in the large societies, and the expenditure of time and money required to attend their conventions, are to the young man, especially if he be located a long distance from the place of the convention, often more than he can well afford. Furthermore, these four societies, with their large lists of members drawn from every part of the United States, are of necessity unwieldy, and the identity of the individual who attends one of their conventions is so merged into the mass that he is known rather by his number than by his name. In a word, the young engineer, even if he can afford to join one of these societies, feels himself out of his class, and is often lonesome and ill at ease at its conventions. His papers, should he summon courage to write them, might, very properly, be rejected by the publication committee. Should his paper be accepted, the writer might have the mortification of hearing it discussed by an older man, his superior in debate and in knowledge of the subject, who, not being acquainted with the author and differing from him in his views, might so attack the paper as to cause him much heart-burning and humiliation.

But the young engineer needs professional intercourse with his fellows to broaden his views and increase his knowledge. He wants to try his wings, and he needs the kindly helping hands of older men, who know something about him and are interested in him, to guide him in his first efforts. One cannot learn to swim without going into the water; and so the young engineer who, for any of the reasons given above, is not able to bring himself to join one of the larger societies and take part in its proceedings, might, if dependent upon those societies alone, be compelled to get along for years without that practice in written and verbal debate which is so essential to perfecting his attainments. Just here lies the best field of usefulness of the minor engineering society. Many of these societies are state organizations and for convenience they may be here classed as such, to distinguish them from the larger or national bodies.

The state society offers to the young engineer, at merely nominal cost, just what he needs. Its conventions are short and always within easy reach, its dues are small, and its requirements for admission are designed to exclude only those whose personal characters or habits are objectionable. Its membership is relatively small and is made up of men from one state, all of whom have something in common and most of whom know each other. In each of these societies there are usually enough men of high reputation and attainments to give a good tone to the gathering; and these men always stand ready to make the young engineer feel at home and to draw out the best that there is in him. His papers, when he reads them, will be listened to with more attention than he could expect in one of the national societies, and will be discussed with that kindly consideration for their short-comings which can come only from personal interest in the author. The state engineering society, therefore, offers to the recent college graduate an excellent post-graduate training, and for this reason deserves, and usually receives, much encouragement from those broad-minded professors whose interest in their pupils does not cease with the signing of their diplomas.

While the best field of usefulness of the state society is probably to be found in helping the younger engineers, there are many older ones who can be reached by it alone. There are many worthy men who have been for years practicing their profession in a modest way, perhaps as engineers for small cities or towns or as county surveyors, in localities so remote that they have not been able to acquire either the money or the attainments necessary for admission to the national societies. These men naturally turn to the state society for aid and comfort. And, on the principle that it is more blessed to give than to receive, the state society helps materially, and in the highest sense, the engineer of high reputation who joins it to encourage and develop the best that there is in the engineers, young or old, of his own state.

A Serious Aspect of Building Foundations.

From time to time statements have appeared in papers before engineering societies and in reports of the examinations of sub-surface conditions in cities, which have by no means received the consideration that their importance warrants. It is not improbable that in some cases the full significance of the facts revealed by these investigations has been unappreciated even by those making the examinations. In a general way it is recognized that the delving and burrowing into the ground on which our large cities stand have produced some change in the load-bearing capacity of the soil. Sometimes it has been increased and more often it has been decreased by the presence of lofty structures with deep basements and cellars going down in places four or five stories below the level of the street curb. All these excavations for buildings and the construction of deep conduits for sewerage, drainage, railway and other purposes have resulted in an appreciable change in the normal height of the ground-water table. In parts of some of our cities the ground at the street level overlies small valleys in which brooks formerly flowed, and while these brooks disappeared during the gradual filling-in of their courses the latter remained effective controlling influences on the ground-water in their neighborhood. Since the cellars of buildings and various subways have been cut through the sides of these old valleys and the soil has been rendered more permeable to the passage of water, the old drainage lines have become less important, and it will no longer be safe to rely wholly on former experience concerning the depth at which water will always be found. The importance of this condition is apparent when it is considered that many large and heavy buildings are constructed in these cities each year on pile foundations. The piles are cut off below the ground-water table, and it is assumed that they will be practically indestructible. That this belief is not justified with such extensive sub-soil excavation as takes place in a large city is shown by the condition of the timber piles in a large and important building about fifteen years old. When this structure was erected, the piles were cut off about 2 ft. below the normal water line. When some of them were uncovered recently in the course of building operations on an adjoining plot, their tops were not only dry but badly decayed, because the ground-water had sunk several feet since the building was erected.

The enormous weight of a building of this class is largely carried by the piles during the first few years after its erection, but it may be questioned whether the piling does not have a less important part to play as years pass on. Instead of the earth being comparatively loose, it may become hard and stable under the heavy continuous pressure on it. The piles driven closely in it tended to consolidate it at first, and a very slight settlement would be sufficient to finish the consolidation. Consequently the weight may be assumed as resting directly on a very firm mass of earth rather than on piles which distribute it downward for thirty or forty feet through skin friction. While such an assumption is necessarily pure conjecture, it is justified by the fact that one of the most famous office buildings in this country has received little or no support for some years from the piles which were intended to carry it, for their tops are so punky as to give way under a light pressure.

There will always be localities where the use of timber piles will be justified on the ground of safety. These places are near bodies of water having a permanent level which is known to influence the level of the ground-water at the building site. It will not do to assume, however, that because a building is near a water-front that its ground-water level will be materially affected by the body of water. For example, in building the new custom house at Bowling Green, in Manhattan, only a few hundred yards from the tip of the island, there was hardly any difficulty in keeping the excavation dry, although a subway running under the East River lies in the immediate neighborhood and might naturally be expected to open up some considerable passage for the water to reach the site.

If there is any probability that the water-level in the site will change and the weight of the building to be carried is great, it would seem that prudence should require some other class of foundation than timber piling. Formerly the substitute has been caisson foundations built by various means. These are excellent, but too costly for the requirements in some places and not adapted for the conditions in others. Consequently the concrete pile remains the logical substitute for the timber pile in many places, for it serves all the purposes of the latter and possesses much greater strength and durability when properly constructed. The expense of substituting concrete piles for timber in the foundations of an important building is an insignificant percentage of the total cost of the structure, and is an assurance of safety against fluctuations in the ground-water table.

Sewage Disposal at Columbus.

The intimate relation between science and engineering was never better shown than in the investigations carried on at Columbus to afford the data for the design of the sewage disposal works of that city described in this journal last week. These works mark a distinct forward step in sanitary engineering in this country, as important as that which was taken by the Massachusetts State Board of Health when it determined the nature of intermittent filtration. From a practical point of view the advance is still more important, for the work done at Columbus shows that entirely satisfactory results can be secured with sewage like that of this city at an expense far below the minimum with intermittent filtration except under unusually favorable natural conditions, wholly absent in most parts of the country. The experimental work demonstrated that uncovered septic tanks and sprinkling filters could be used in the open air in the cold winter climate of northern Ohio, and advantage was taken of that fact to design a disposal plant of unique character.

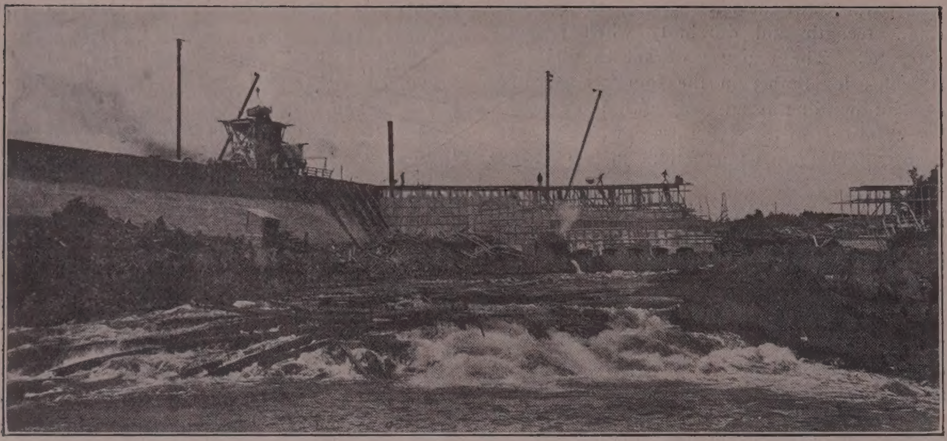
When Messrs. Alvord and Griggs made the first report on sewage disposal at Columbus, about seven years ago, they advised the use of double filtration through coke breeze filters. They recognized that intermittent sand filtration would be enormously expensive there, and accordingly recommended a method of treatment which was then in favor in Great Britain and had been used to a limited extent here in very small works. No action was taken on this report, and nothing was done for some time. Then Mr. Hering was retained to review the whole subject, and about five years ago advised the construction of septic tanks and intermittent filters. This recommendation was coupled with a suggestion that the importance and novelty of the problem warranted the city in proceeding slowly, the proper course being to construct a small part of the plant and operate it experimentally until the best treatment was discovered, when the remainder of the works could be designed so as to conform with the requirements. This suggestion was given much study, but before any decision was reached such a large number of new and promising methods of treatment were discovered here and abroad that Mr. Griggs persuaded the Board of Public Works to have a thorough experimental study of the subject made under the direction of Messrs. Hering and Fuller before designing any works. Such investigations had been carried on in a number of American cities prior to the design of water purification works, but Columbus was the first to adopt this sensible and money-saving plan with respect to sewage disposal.

The results have more than justified the cost of the research. There was a time when some Columbus citizens were inclined to question the usefulness of a municipal research laboratory carrying on scientific studies which they could not understand. Now that these studies are known to have saved the city hundreds of thousands of dollars in initial charges for disposal works and a very large sum for maintenance, there is little disposition to quarrel with the plan that was followed. It has been so successful, in fact, that it may be seriously questioned whether any city will find it advisable to design large disposal works without sufficient preliminary experiment to determine accurately just what the problem is that must be solved. The time has now gone by when any city can afford to disregard the lesson taught by the experience at Columbus.

The works which will be built in the Ohio capital were so thoroughly described last week that it is unnecessary to repeat any of the description here. Attention may well be called, however, to the extreme flexibility of the plant, which permits a great variation in the treatment so as to meet all conditions that are likely to arise. While the first cost of the works will be far less than the estimated expense of septic tanks and intermittent filters, which were proposed some years ago, they nevertheless permit the treatment to fit the character of the sewage just as closely, if not even better. This is a matter that deserves attention, for the common lack of knowledge concerning the variations in the character of the sewage of a large city is as great as the lack of appreciation of the different natures of sewages of different cities. Speaking in a general way it may be said that the investigation which led up to the actual work of design and the designs themselves afford the best illustration yet given in this country of the important results following the application of scientific methods to sewage disposal problems.

The New York Central Lines will hereafter be the title of the 54 railroads controlled by the Vanderbilt interests, with the single exception of the Nickel-Plate (the New York, Chicago & St. Louis), whose charter in the State of Ohio renders a consolidation even of names illegal.

A Pumping Engine to run 24 hours a day should be more economical in fuel than if the time of running is limited to a few hours, and a much larger amount of money can profitably be invested in securing the economical type of engine. In many of the smaller water-works stations the capacity of the engine selected is sufficiently great so that provision may be made for future increase of supply and the necessary amount of pumping may be performed by working only a few hours each day. These practical considerations must have the first place whether the type of engine selected is economical in fuel or wasteful; but the bearing which they have on the ultimate economy of the engine may be overlooked. In such a case the interest on the money invested in an expensive though economical plant will very soon be sufficient to balance any saving of money due to the increased fuel economy, especially if account be also taken of the depreciation and repairs. Take, for example, the case of a 2,000,000-gal. pumping engine where the cost of fuel is $5 per ton. If we suppose the water is pumped against a head of 265 ft., and the number of hours of work is six each day, the difference in economy of fuel produced by a 60,000,000-ft.-lb. duty, which can be realized by an ordinary compound duplex condensing pump, and a duty of 90,000,000-ft.-lb., which can be attained by some form of high-duty pump, would be, in round numbers, $500 per year, and this is sufficient to pay an interest and depreciation charge at the rate of 12½ per cent. on only $4,000. Should the cost of the more economical engine exceed that of the low-duty engine to the extent of $4,000, there would be no real economy secured unless the number of hours of pumping each day exceeded six. If the committees who are empowered to purchase pumping engines would consider this question in its true light it would not infrequently happen that the selection of an engine would fall to the less economical machine.



View Looking Upstream at Dam on Island and across Main River Channel.

RAPID CONSTRUCTION OF AN INDUSTRIAL PLANT.

The Methods Followed at the St. Croix Paper Company's Works, Spragues Falls.

Last February the St. Croix Paper Co. decided to build a pulp and paper mill at Spragues Falls, Me. The project had been talked over in a general way by the company and its engineer, Mr. George F. Hardy, of New York, but no working plans had been prepared when the decision to build was suddenly reached. About the time Mr. Hardy's engineering staff began work on the detail drawings a contract was let to Mr. Frank B. Gilbreth for the construction of the plant and a considerable portion of the mill village which had to be built for the employees. This contract affords an instructive example of the advantages of the cost-plus-fixed-sum method of executing work, the plans not being far enough advanced to receive lump sum bids. The company wanted a concrete dam 2,000 ft. long, a 75-ton ground pulp mill, 70-ton sulphite mill, 75-ton two-machine news paper mill, with all the accessories for such a plant, including a town with macadamized streets and houses for 2,500 people. To wait until the plans could be prepared in sufficient detail for bidders would entail a serious loss of time, and probably make it impossible to get the buildings closed in before winter, which was very desirable. The owners wished to have the plant in operation quickly, and this aim could best be attained by avoiding outdoor work in Northern New England in winter, although the installation of machinery indoors could proceed then without difficulty. Under such circumstances it is manifest that the award of a contract on the cost-plus-fixed-sum basis offers exceptional advantages in the way of hastening construction.

The site of this mill is at a point where originally there was a fall in the river of about 16 ft., which has been increased by the dam to 45 ft. The company is associated with others in a corporation practically controlling the entire stream, which has been dammed at a number of places in order that its flow can be regulated. The works at Spragues Falls start on the Canadian shore in a concrete dam about 25 ft. in maximum height and 550 ft. long, which runs across the main channel of the stream to an island. Here it makes a turn of nearly ninety degrees, as shown in the illustration above, and runs downstream over it for a distance of about 250 ft. to another turn of over ninety degrees. Near this bend is a log sluice and beyond it are the buildings of the plant, their upstream foundation walls serving also for the dam which runs to the American shore. These buildings are the grinding room and electric plant at the head of the tailrace, where the turbines are located, and then in order, the wood preparing and wet machine room, blowpits, digesters and acid plant; the beater room, boiler house, machine room and finishing room are located back of the sulphite pulp plant, away from the dam.

When the contractor and his staff reached the site of the plant about ten months ago, the ground was covered with about eight or nine feet of snow. After examining the locality so as to determine the general arrangement of their plant, work was at once started on the construction of a camp. Contracts of this character differ very much from a railroad contract, for example, on account of the great variety of work done. This causes complication because the bricklayers, masons and other groups of workmen, down to the Italian shovelers, must be quartered separately if the greatest efficiency is to be attained. The buildings first put up were necessarily built on the snow, and as this melted they were blocked up until it was possible to lower them safely to the ground. The spur track from the railroad was also laid on the snow, and as the latter melted it was allowed to settle with the snow, without interrupting its use. While this work on the camp was in progress, the contractor was also engaged in perfecting the details of his organization. All these arrangements were indicated by a chart, which showed the relations of every man on the work to the others and to the central office. The position of the superintendent, clerk, timekeeper, superintending mason, superintending carpenter, foremen and workmen are all shown by a diagram, arranged on the same plan as a genealogical tree. These charts were posted in conspicuous places so that an employee on any part of the work could see his position in the general organization and the relative rank of those over him.

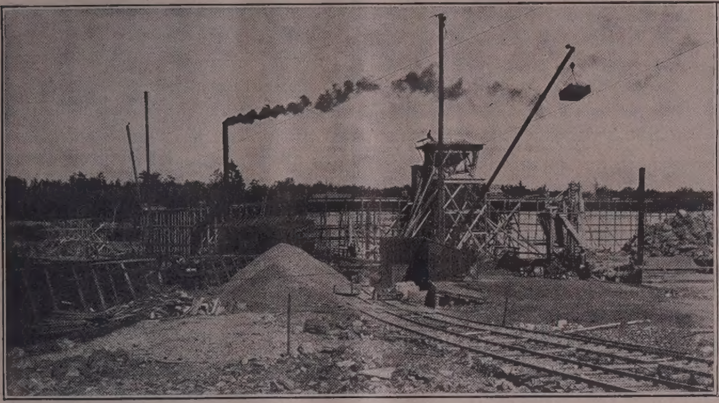
Work was started in April in the tailrace, where a considerable amount of rock excavation could be done advantageously, not only for the purpose of deepening the channel, but also to furnish stone for the large amount of concrete used on the work. Much of this concrete was made with large rubble stones embedded in the concrete after being carefully cleaned and washed. In order to carry on the tailrace excavation and protect the site of the buildings an old crib-dam was built to guide logs away from the channel was reconstructed and enlarged. The new parts and a bulkhead running downstream on the river side of the tailrace were built by lumbermen, experts in this kind of work, and were floated into place and sunk with rock excavated from the tailrace. A great deal of blasting was done on the excavation and part of it was near one of the boiler houses supplying steam for various construction purposes. This house was accordingly built of logs, so that when it was struck by pieces of rock, sometimes weighing as much as a hundred pounds, they would be thrown off by the spring of the heavy timbers.

The natural lay of the land was utilized as much as possible in starting the work. The island was bare and the work on it could be carried on without serious trouble from the outset. From the island to the American shore, the early construction of the coffer dam enabled the construction to be pushed rapidly and without other interruption than necessarily attends the execution of work in a remote locality and subject to delays while the owners decide details which must be settled before all the working plans can be drawn. The main dam from the island to the Canadian shore was at first designed as a timber structure and materials for its construction were being assembled when the owners determined to make it a concrete dam. This made it necessary to secure additional concrete plant and to otherwise change the working scheme, so that this part of the work is not yet complete, although nearly so. One of the accompanying views shows the line of this dam from the island to the Canadian shore, and indicates the considerable amount of work done in the Dominion. This was started early and was attended with some inconvenience on account of the international custom-house requirements. At first men and materials were transferred across the channel by a ropeway, but later cribs were sunk in the channel and connected by timbers so as to carry a roadway. The cribs were used later as part of the upstream coffer-dam for protecting the main dam. Some of the materials used on the Canadian side were bought there, and those hauled over from the American side were reported every night to the Canadian customs authorities. A stable had to be built for the horses because there is a Canadian law forbidding feeding and bedding horses used on American territory.

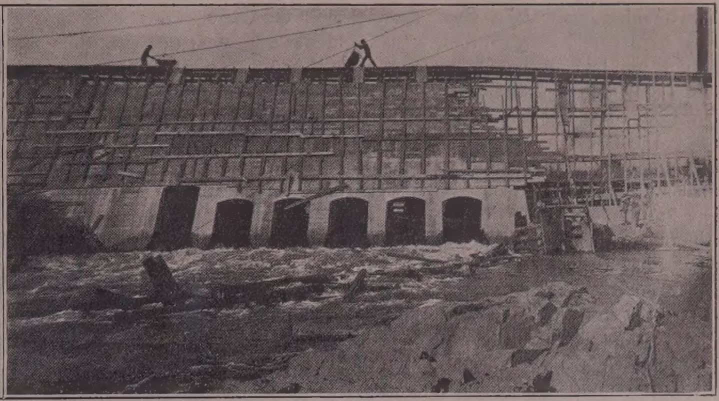
One of the concrete plants had a drum mixer located on the island near the angle where the main dam bends to cross over to Canada. There was also a batch mixer located on the island some distance upstream from the dam, at a place from which the material could be delivered readily to various parts of the work. The large plant shown in the views of the dam had an automatic measurer and feeder designed by Mr. Gilbreth several years ago, and used by him on a number of undertakings.

The broken stone was crushed near the mixer, screened and delivered into the hopper bins, from which it was run into derrick boxes and hoisted to the platform of the concrete plant as required. Sand was delivered from the American side by a gravity railway several hundred feet long. The concrete was wheeled from the mixers in two-wheeled carts holding about 9 cu. ft. each, and the trestle platforms shown in the pictures illustrate the facilities for this part of the work.

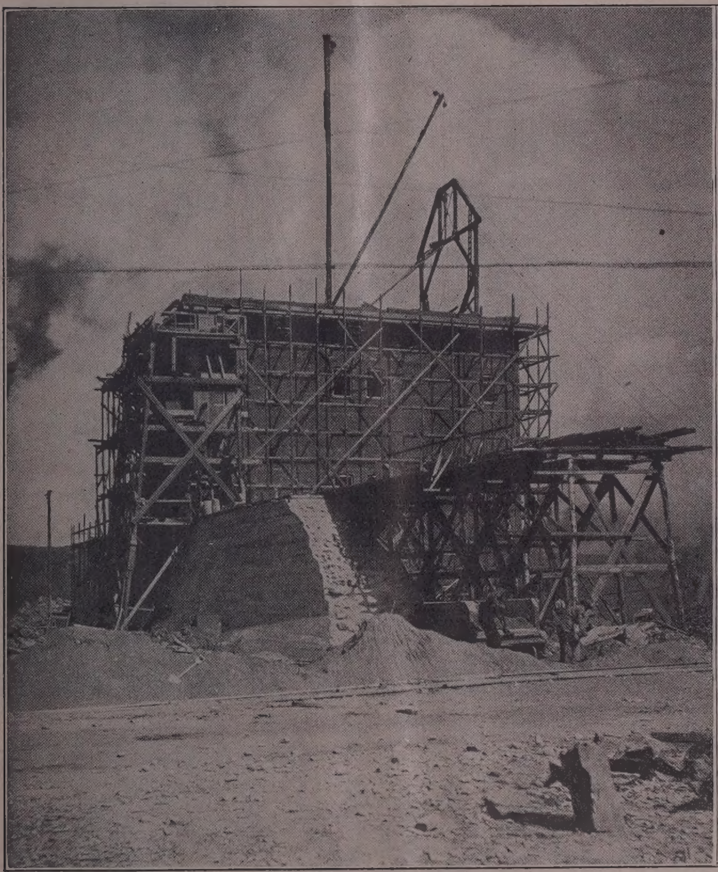
The concrete for the main dam was mixed in the proportions of one part of Iron Clad Portland cement, three parts of sand and five parts of broken stone. It was very wet and no tamping was done except close to the forms. Large blocks of stone were placed in it after being cleaned, which resulted in a considerable reduction in the cost of the concrete in this case. The total cost of about 6,000 cu. yd., including the expense of crushing the rock, the materials and labor in building the forms of tongue-and-groove plank, and the cost of all other items properly charged to this part of the work, was about $3.20 a yard.



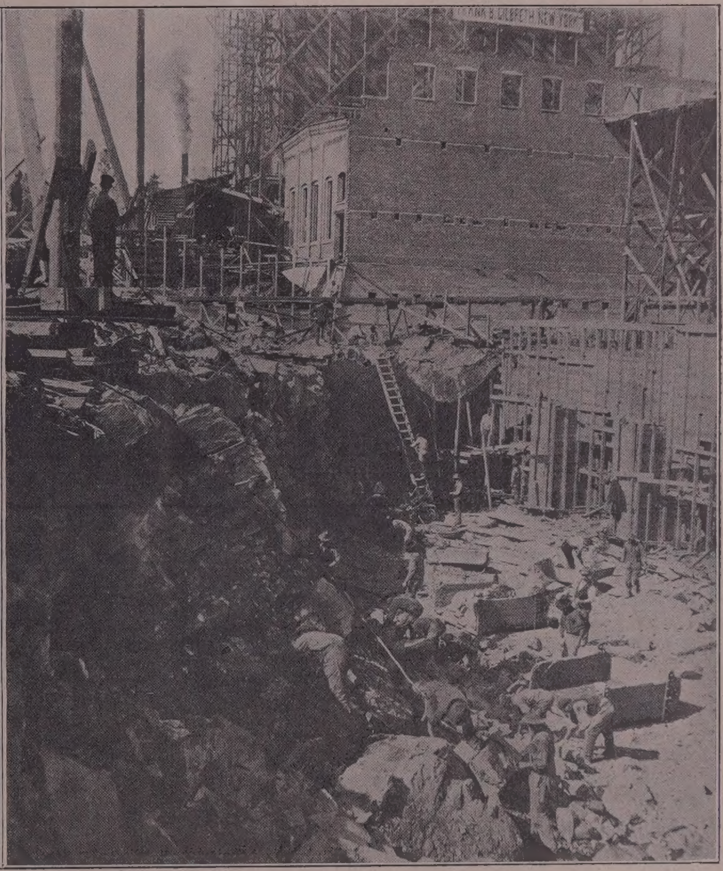
Concrete Plant on Island.



Construction of Main Dam.



Part of Digester House and Dam.



Excavation at Head of Tailrace.

The dam across to the American shore was built in alternate sections, with dovetails on the ends so that when the intermediate sections were built the whole structure was locked together into a single unit. The main dam across to the Canadian shore was started behind coffer-dams which enabled a section with a sluice to be put in. The river was then turned through this sluice and the work continued. There are six of these sluices in all, which enable the river flow to be controlled without any trouble, although provision was made for handling a flood if one had occurred. The Washington County R. R. crossed the line of the main dam on the Canadian side and was kept in operation through a gap in that structure until a new line farther from the shore was built. A platform carried the workmen's runway over the track and was hinged so it could be moved out of the way to allow trains to pass.

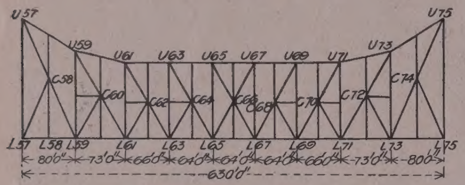
While the plant itself was under construction a town had to be built, which was done partly by Mr. Gilbreth, partly by Maine contractors and partly by the company's own force. In undertakings of this nature it is as necessary to organize a village as to construct the manufacturing plant, for labor must be brought to the place. When the contract for constructing this mill was signed last February, the only thing at Spragues Falls was a sign post. The nearest house was about two miles distant. A forest stretched away for miles in every direction. To-day there are good streets, about 250 houses for one and two families, a boarding-house for unmarried men, several stores, a good hotel with private bathrooms and other conveniences, a hospital, a church, a school, and ample railway stations and sidings. It has all been done so quietly that a few days ago a large moose, wildest of forest animals, was shot only a few hundred feet from one of the houses, a fact that will convince sportsmen of the newness of the town.

These facts are mentioned as illustrating one phase of the problem which confronted the builders of this plant. Its construction in a more settled section of the country would have been much less difficult. Instead of having to depend for transportation on a little branch railway in a remote corner of the country, there would have been plenty of facilities of all kinds. Workmen could have been secured without much trouble without going far for them, and tools and supplies could be procured as needed. In this case, there was not a single facility on which a contractor could rely. Everything had to be brought to the work long before it was needed, and in order to be on hand when required its use had to be foreseen. Working in this way, without a single detailed plan ready for use when the contract was signed about ten months ago, the practical completion of the dam and buildings to-day is an example of engineering and contracting ability that deserves the consideration of the old school of manufacturers, who take a year to plan a leanto and a decade to plan a blacksmith's shop. The achievement is a proof of the fact that the manufacturer who desires a new plant in a hurry will do well to turn its design over to an experienced mill architect and its construction to a contractor who has an organization ready to take up and drive the work to speedy completion.

The Lower Chords of the Island Span of the Blackwell's Island Bridge.

Blackwell's Island bridge across the East River, between Manhattan Island and Long Island at 59th St., New York, has five main spans with a total length of 3,724 ft. and a width of 90 ft., which will contain about 90,000,000 lb. of steel and will carry eight railroad and street car tracks, a carriageway and two sidewalks. Each river channel will be crossed by a single long cantilever span and these two spans will be connected by a 630-ft. island span 118 ft. deep in the middle and 185 ft. deep at the ends. Like the other spans this one has two pin connected trusses in vertical planes 60 ft. apart and is made with long sub-divided panels with a riveted bottom chord and eyebar top chord.

The bottom chord of the island span is made continuous with those of the adjacent cantilever arms and has a reversed camber of 4½ in. between the pier posts. This is so that under the dead load stresses from its own weight and the weights of the two adjaent cantilever arms the camber will exactly equal the deflection and the bottom chord will assume a horizontal line except for the comparatively small deflections due to live loads. It is made in sub-panel lengths of from about 31 ft. to 59 ft. long with riveted splices clearing the panel points. The stresses from the dead load of about 35,000 lb. for the island span, the assumed live loads of 8,000 lb. per lin. ft. regular and 16,000 lb. per lin. ft. congested, and the assumed wind pressure of 2,000 lb. per lin. ft. develop a maximum total lower chord stress of 20,500,000 in panel 57-58, which is provided for by a cross sectional area of 1,067 sq. in. The minimum lower chord stress is 13,340,000 lb. in panel 67-69 with a corresponding area of 651 sq. in. The end panel, 74-75, has a maximum stress of 13,675,000 lb. and an area of 711 sq. in. The bending stress due to the weight of the member was computed and found to give an extreme fibre stress of only 1,300 lb. on outer fibre.



Island Span.

The chord has a uniform width of about 6 ft. 10 in. and is 4 ft. 1¾ in. deep over all, is made with four vertical webs throughout and has a radius of gyration of 14.5 in. The maximum lower chord section in the entire bridge is between panel points L17 and L18, adjacent to pier I. It has a cross section of 1,120 sq. in. and weighs about 130,000 lb. The lightest lower chord sections are at the ends of the cantilever arms and have a cross section of 75 sq. in. In order to bring the heavy chord sections within the limits of handling and shipping they are made in two pieces with a field-riveted longitudinal center joint from end to end and the pieces are shipped separately and assembled and field-riveted on the falsework.

Lower chord section L57-L58 extends 58 ft. 8 3/16 in. from a point 12 ft. 7½ in. on the shore side of the center of pier II, to a point 6 ft. ½ in. on the river side of L58, having a length 3/16 in. in excess of the 40 ft. theoretical distance between L57 and L58 to provide for the camber. It is made up with four massive built channels composed of full length angles and plates connected together in pairs with shop-riveted top and bottom flange lattice and tie plate, by vertical transverse diaphragms, and the pairs connected with field-riveted diaphragms and short horizontal tie plates.

Each outside channel is made with two 6x8x⅞-in. flange angles, four 48x⅞-in., one 45½x¾-in., one 45½x⅝-in. and one 31x⅞-in. web plates, seven web plates in all, with a combined thickness of 5¾ in. The inner channels are each made with two 6x8x⅞-in. angles and four 48x⅞-in., one 45½x¾-in. and one 31x⅞-in. web plates, making a total thickness of 5⅛ in. The plates are riveted together with six staggered horizontal rows of 1-in. rivets with maximum pitch of 9½ in. between rivets in the same row. The flanges are connected by shop-riveted double latticing of 5x⅝-in. bars with two ⅞-in. rivets at each end and one rivet at each intersection. They are also connected by regular 37x⅝x72-in. tie plates and by special tie plates of the same thickness but greater lengths and widths at sub-panel points and at lateral strut connections. The webs of each pair of channels are connected by six diaphragms each having an I-shape horizontal cross section and made with a 30x½x17¾-in. planed-edge plate and four 4x4x½-in. vertical connection angles. The two longitudinal halves of the chord section are riveted together by 26 15x½-in. plates 18 and 24 in. long, which are field-riveted to the under side of the top flange angles and to the upper sides of the bottom flange angles opposite the main tie plates. They are also connected together by five diaphragms similar to those between the pairs of channels except that they have only two connection angles each. At L58 there is no pin connection and the sub-vertical post is field-riveted to the top flange cover plate through horizontal connection angles; additional connection is also afforded by field-rivets through vertical angles shop-riveted to the transverse diaphragms and projecting above the chord through holes cut to clear them in the top flange tie plates. The bottom flange tie plates are special at L58 and project 29 in. beyond the inner edge of the chord to form lower jaw plates receiving the ends of the bottom lateral struts. The upper jaw plates are field-riveted between pairs of horizontal 6x6x½-in. angles 5 ft. 3 in. long shop-riveted to the webs of the outside channels. The splice at L58 is made with faced butt joints between the ends of the chord sections which have a combined thickness of 22 11/16 in. and are connected with four 37x⅝x57½-in. horizontal and two 48x½x53½-in., four 45½x½x37½-in. and two 48x½x37½-in. vertical splice plates with 308 1-in. and 112 ⅞-in. field rivets. The splice at L57 is similar.

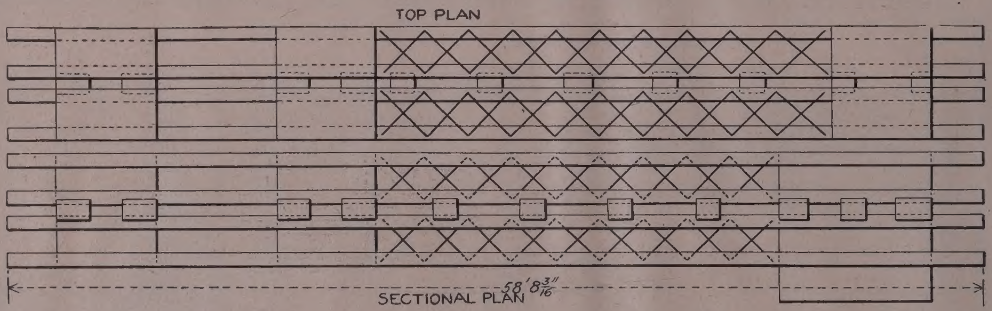
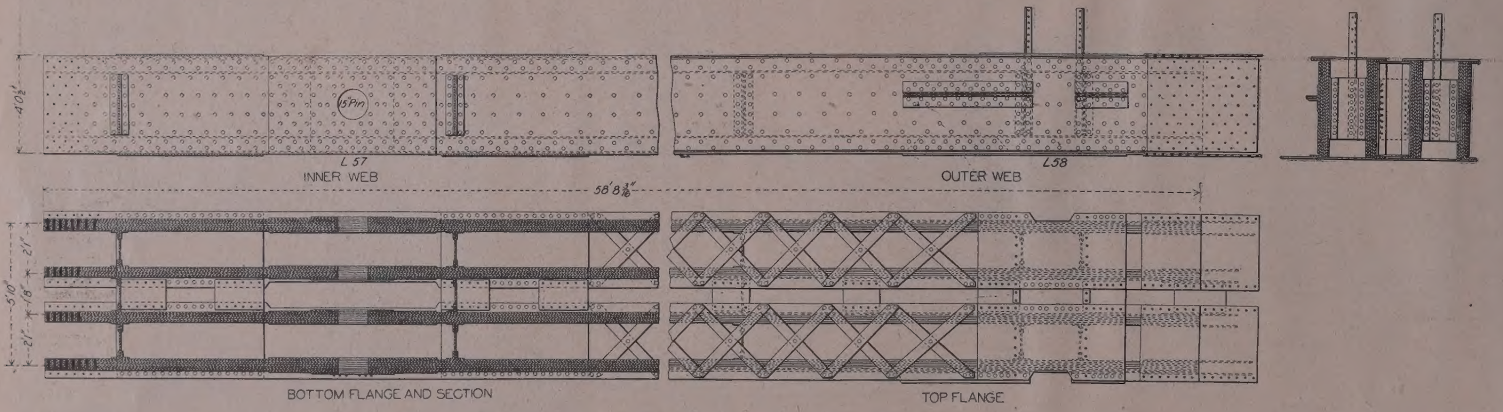


Diagram of Field Connections between Halves of Lower Chord.



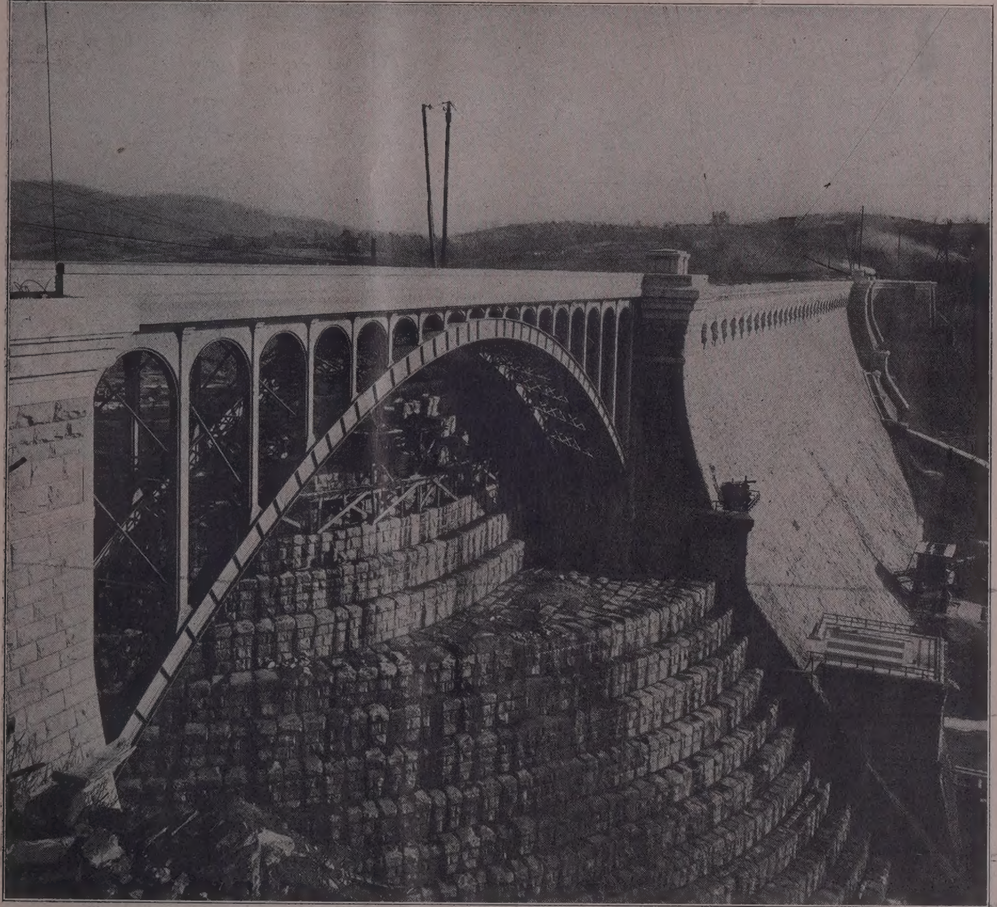
Typical Lower Chord, Island Span.

As the main posts at Pier II are not vertical and their feet are 95 ft. apart on centers the bottom chords are not directly connected to them, but are carried on the horizontal transverse girder, from which they are supported by cast steel shoes with four webs which engage the 15-in. chord pin, receiving the inclined sub-posts of the island and anchor-arm spans and the vertical post which carries the upper deck here. The other sections of bottom chord correspond very closely with the one here shown and have pins from 14 to 18 in. in diameter for the connections with the main verticals and diagonals while all the sub verticals are connected with field-riveted flange joints as shown at L58. All rivet holes except in the lattice bars, tie plates and diaphragms are punched and reamed ¼ in. and all sheared edges of plates are planed off ¼ in. All material except for rivets is open hearth basic steel with an ultimate strength of 60,000 lb., elastic limit of 36,000 lb., elongation of 30 per cent. It is required to conform to the usual reaming, bending and drifting tests and contains a maximum of .04 per cent. of phosphorus and .05 per cent. of sulphur.

The design and erection of the bridge is under the direction of the Department of Bridges of New York, Mr. George E. Best commissioner, Mr. O. F. Nichols chief engineer, Mr. R. S. Buck consulting engineer, and Mr. J. D. Wilkens engineer in charge. The contract for the manufacture and erection was awarded to the Pennsylvania Steel Co., Mr. J. V. W. Reynders superintendent of the bridge and building department. A general description and elevation of the bridge was published in this journal March 4, 1905, and details of the main towers and floor platforms were published May 20 and 27 and June 10.

Completion of the New Croton Dam.

Work is now drawing rapidly to a close on the new Croton dam, which was commenced more than thirteen years ago, and will have cost over $8,000,000, exclusive of the land and inclusive of some fifteen miles of highways, several bridges and important changes involved for the old Croton aqueduct. This makes the dam construction proper foot up to something like $7,500,000, of which over $1,000,000 is due to the change from earth to masonry of the south end section. It will be remembered that the dam is exactly 300 ft. high from the lowest point in the foundations to the crest, and is thus the tallest dam in the world. It forms a reservoir 18 miles long and impounds about 32,000,000,000 gallons of water It is built of solid granite ashlar and rubble, except that the south extension is backed with cyclopean concrete, and it has a spillway 1,000 ft. long at right angles to the axis of the dam and 16 ft. below its crest and contains altogether about 855,000 yds. of masonry. The spillway is crossed by a steel arch bridge of 200 ft. span, described in The Engineering Record of Oct. 21, which has been designed and painted to harmonize as closely as possible with the granite masonry, an attempt which has been notably successful as far as color and the continuity effect of the dam cornice is concerned, but which emphasizes the comparative slenderness of the arch rib in relation to the massive buttress formed by the dam at one end and by the hillside at the other end.


Main Dam, Spillway and 200 Ft. Arch Span.

The contract for the construction of the dam was awarded in August, 1892, and since then there has always been employed a large force, sometimes amounting to nearly 1,000 men, at the dam and quarries; a very large mechanical plant with over 700 h.-p. of steam boilers installed; important auxiliary works have been executed; two large quarries have been opened and many interesting operations have been conducted which, as examples of high-grade construction, advanced methods and extensive plant, have been described in a number of articles in these columns.

A large power plant was permanently installed a short distance below the dam site. The river, which had a flood flow of 15,000 cubic ft. per second, was diverted by means of a canal 200 ft. wide and 1,000 ft. long in rock cut with a crescent-shaped wing dam at each end built of earth, stone, piles and cribwork. The upper dam was 30 ft. high and joined a masonry wall 23 ft. high and 630 ft long. These barriers excluded the water from a pit excavated 150 ft. below the old river bed and drained by a battery of seven steam pumps which raised the water from the deepest part in two lifts and sometimes handled as much as 10,000,000 gallons in 24 hours.

Earth was excavated by hand and by steam shovels and was removed to the adjacent spoil banks by teams, by locomotives, by an inclined plane and hoisting engine serving depths of over 70 ft. and finally by three cableways about 2,000 ft. long parallel with the axis of the dam and nearly 300 ft. above the lowest excavation. The gneiss and limestone rock underlying the earth had a very irregular surface and much of it was so unsound that it had to be excavated to a considerable depth and very interesting work was done in filling the fissures and seams with concrete and cement and in handling the strong springs which rose through them to a considerable height.

The masonry was laid by the aid of the cableways and about thirty large stiff-leg steam derricks, which were carried up on the top of the masonry as it progressed.

The south end of the dam was originally designed and partly constructed with earth embankment and a core wall. It was finally determined to change it to solid masonry, and as the foundations which had been suitable for the original structure were considered inadequate for the greater weight of the stonework the excavation was carried down much deeper and passed through a very interesting deposit of disintegrated rock which existed at a considerable depth below the surface. A large plant was erected for crushing stone, screening sand and mixing concrete and work was carried on during cold weather with special provisions against freezing concrete and mortar.

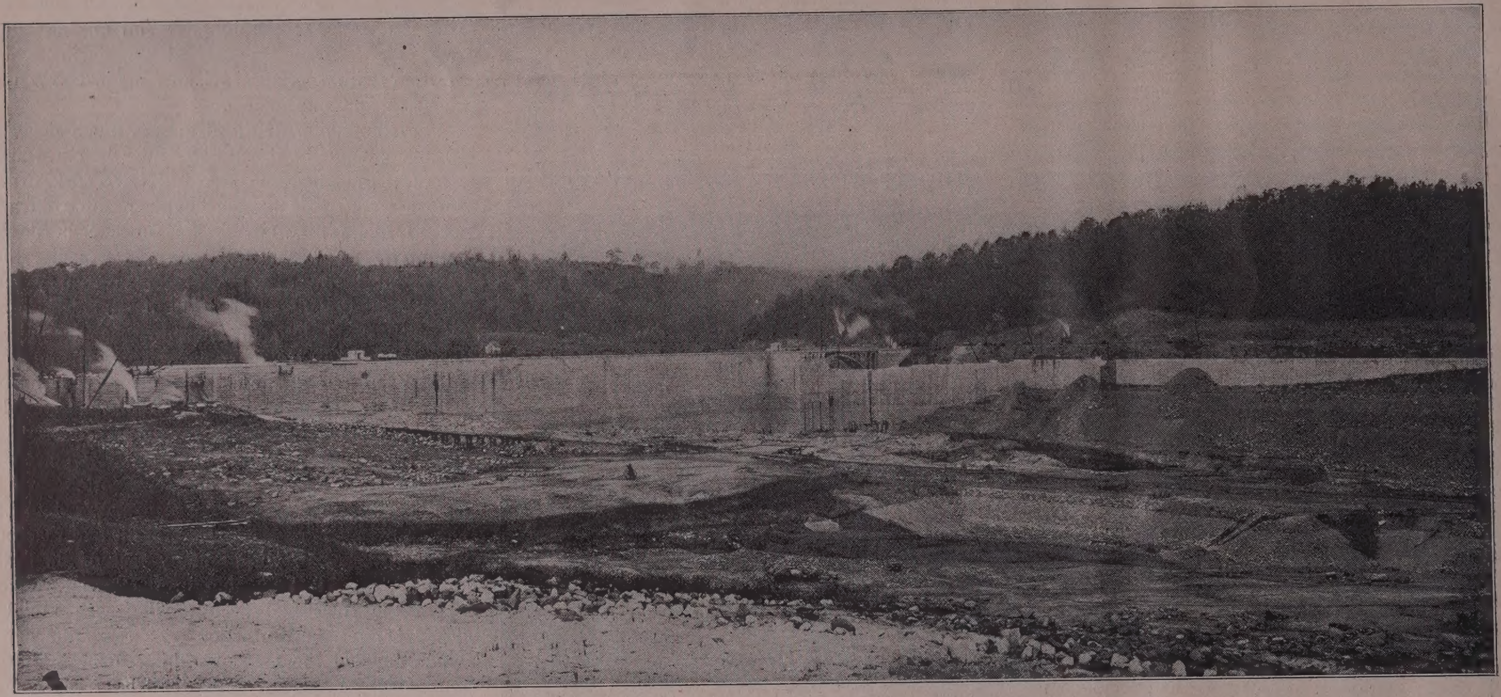
The completion of the dam was much delayed by the change in its design and when a water famine threatened the city of New York great efforts were made by the engineer and contractor to make it available for storage purposes before it was wholly finished. To expedite the work, steel towers were erected to carry the derricks in advantageous positions and were permanently built into the masonry as the latter rose above and around them. This scheme not only saved considerable time but added materially to the strength of the dam and was considered so satisfactory that it has been proposed to adopt the same method in other large masonry structures in the vicinity of New York.

When the dam masonry was considered to be above any probable flood but before it had reached in some places to within many feet of its final height, the arched opening in the base through which the river had been flowing was rapidly closed behind the protection of a low cofferdam which enabled the masonry filling to be built so as to form its own protection and be safely completed from the upstream to the down stream face of the dam. After this was accomplished about 1,000,000,000 gallons of water, sufficient for 30 days' supply for the city of New York, was stored and used during last summer, thereby greatly augmenting the reserve supply which, at best very low, would have been dangerously so without this provision.

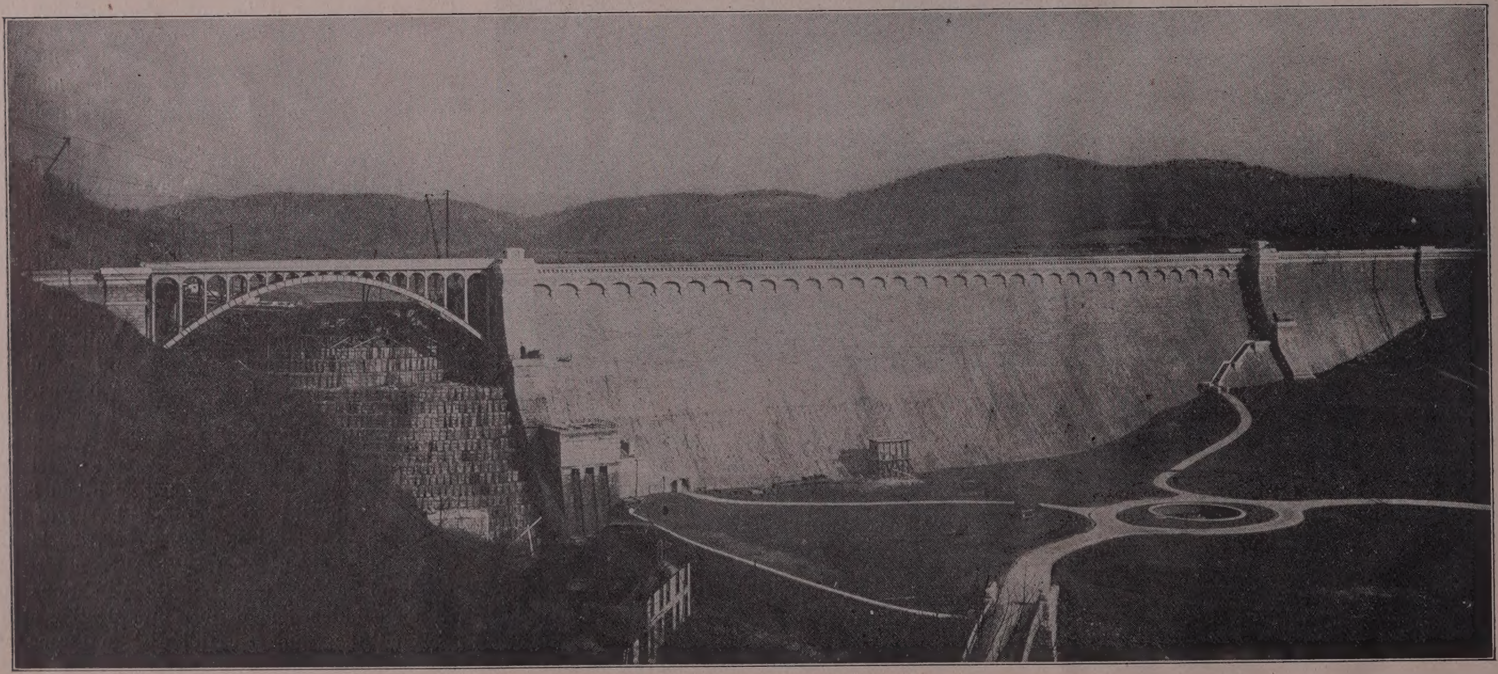
The valley above the dam was cleared of trees, brush and buildings to make a reservoir 157 ft. in maximum depth to store the water impounded by the dam. A large amount of vegetable matter was of course submerged as the water collected and in the hot weather it commenced to decompose. Before this occurred the water had been drawn off to the level of the conduit so that although a considerable quantity still remained in the deepest part of the reservoir it was not possibly available for city use and in September it was drawn off and wasted, leaving the reservoir ready to be filled again with pure water by the fall and winter rains. The water had been admitted to the reservoir before the face of the dam had been pointed and submerged, the latter to a height of about 122 ft. When it was drawn off advantage was taken of the conditions to have the pointing done by men on a floating platform and the water was allowed to escape at such a rate as allowed the scaffold to sink just as fast as the pointing was completed.

The depth of the water at the dam is now only about 20 ft. and it is interesting to observe that water forced into the masonry under the heavy pressure is now slowly seeping out of the upstream face between high and low water marks. Nothing like leaks are indicated, but there is a perceptible moisture which is somewhat remarkable considering the unusual excellence of the work and materials and the massive nature of the design.

The face of the dam is built with granite ashlar, in courses from 20 in. to 30 in. in depth with dressed arrises and joints of a maximum thickness of 30 in. made with 1:1 cement mortar. The rubble backing was laid with the utmost care and rigid inspection. The large stones were set on beds of concrete and mortar in which they were fitted by bedding and lifting them again with derricks from three to six times, never less than twice, and usually three or four times, care being taken to fill in plenty of mortar over all irregularities so that the stone had perfect contact throughout and floated easily. Spaces between the large stones were filled with smaller stones carefully bedded in mortar so that no two stones touched each other. The 85,000 cubic yd. of concrete backing in the dam extension contains large stones which were quickly lowered into thick beds of fresh concrete and were then shaken with bars until they were deeply bedded and floated easily in the soft mass. Special care was taken to set all stones with convex faces down, and never to allow any stone to have a cavity in the lower surface in which air might be confined. As the thickness of the dam at the bottom of the reservoir is from 125 to 216 ft. it is not likely that there can be any passage of water through it, but the seepage above mentioned is of interest as showing the great difficulty or impossibility of making stone masonry absolutely impervious under heavy pressures.



Upstream Face of Finished Dam, Spillway at the Right.



Finished Dam, 150 Ft. High above Surface of Ground.

The original bed of the Croton river below the dam serves as a channel for the water discharged over the spillway and is crossed by a 150-ft. arch highway span of plate girder construction having handsome granite abutments and wing walls. A portion of the river bed between this bridge and the foot of the spillway is covered with a concrete apron about 2½ ft. thick to protect the bottom from the impact of the falling water or from objects which may be carried over the cascade. The steps of the spillway are made with very deep courses of granite, many of the blocks weighing ten tons or more, but as some large stones in the spillway of the Sodom dam, farther upstream, have been dislodged in freshets these stones have been additionally secured by anchorbolts reaching through into the next lower course. The same precaution is also being taken now with the large coping stones on the top of the spillway where 2-in. holes 4 ft. deep are being drilled to receive dowels of 1¼-in. twisted square steel. These are drilled at the rate of about 28 lin. ft. a day by Ingersoll rock drills operated by steam from individual boilers.

In order to determine the most efficient method of securing these dowels experiments have been made with 1¼-in. Ransome twisted steel bars set with 1:1 Portland cement grout in holes drilled 2 ft. in granite blocks. The projecting ends of the bars were provided with eyes bored to receive a connecting pin in the testing machine. Pressure was applied with a 100-lb. hydraulic jack set in a special frame, and a load of 60 tons which broke the jaws of the machine, failed to pull the rod out of the block in one case. In another case the rod was displaced slightly by a load of 30 tons and was elongated about 3/16 in.

in a length of 18 in. outside the block but was not pulled out, even with a maximum load of 50 tons.

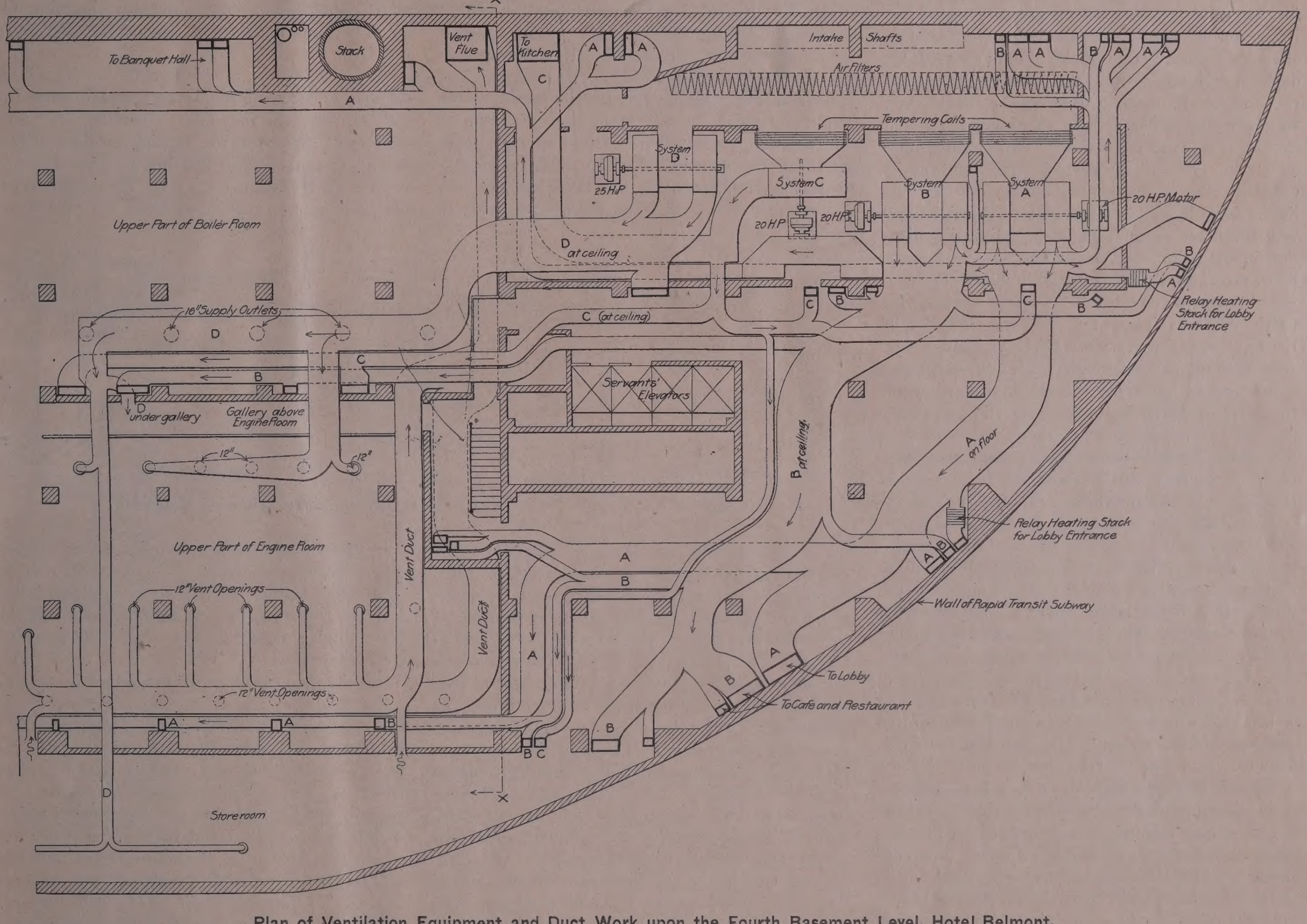
The concrete pavement for the 20-ft. roadway on the crest of the dam is being laid in sections 6 ft. long and about 12 in. thick in the center. The sections are laid in alternate lengths, care being taken to grease the bottom and sides of the beds which receive them so as to prevent adhesion of the concrete to the dam masonry or of one section to the next. The concrete is mixed in a Ransome machine on the hillside near the south end of the dam, 30 ft. below the crest, is hoisted in 1-yd. steel buckets and passed to the required position by several guyed derricks still remaining on the crest of the dam.

The slopes of the back fill on the upstream side of the dam are being paved with large granite stones very carefully laid and bedded on a layer of small broken stone, so as to make a stable, durable protection against erosion and give the work a finished appearance. Near the gate house controlling the old aqueduct a concrete foundation has been built at the side of the roadway as it approaches the dam, and on it there will be placed a pedestal 6 ft. in diameter and 2½ ft. deep cut from a single block of granite. On it an ancient mill stone found at the quarry opened for the stone in the dam, will be placed to support a large granite sun dial.

The slopes of the hillside at the south end of the dam on the downstream side are largely covered with spoil from the 1,440,000 yds. of foundation excavation and this has now been smoothed and dressed and neatly divided by two berms each trimmed to symmetrical lines and drained by a ditch paved with broken granite. The slopes curve in broad sweeps to the face of the dam and their smooth inclines which will be seeded or sodded, present a beautiful appearance in harmony with the grand mass of the dam, which rises like an enormous gray wall to close the valley and in seasons of freshet is flanked at one end by a large river pouring down a 150-ft. cascade formed by the curved spillway steps.

At the foot of the dam there is a fountain with a circular basin 60 ft. in diameter which has one 1-in. center jet and four 2-in. jets clustered round it and rising vertically to heights of about 30 ft. and 35 ft. respectively. The jets emerge from the upper basin of the fountain and as the water overflows and recedes from the lip of the basin it alternately obstructs and partly releases the orifices and causes the jets to pulsate with an interval of about 5 seconds, thus producing automatically a very attractive effect. Around the fountain are paths and macadamized carriage roads with a top dressing of broken granite and a binder of the granite screenings from the concrete crusher which make an excellent road surface, and retaining their white color, contrasts vividly with the green lawn. With the berm ditches and the roads winding up the sides of the valley they add considerably to the view from the crest of the dam or from the approach up the valley.

The dam was designed and its construction commenced under the direction of the late Alphonse Fteley, chief engineer, who resigned on account of failing health, and was succeeded successively by Messrs. W. R. Hill, J. Waldo Smith and W. H. Sears. Messrs. Coleman, Breuchaud & Coleman are the contractors.



Plan of Ventilation Equipment and Duct Work upon the Fourth Basement Level, Hotel Belmont.

Mechanical Plant of tle Hotel Belmont, New York.—II.

Heating System.—The hotel is heated by direct radiation on the upper floors, while on some of the lower floors indirect radiation is introduced in connection with the ventilating systems. The Webster vacuum system of steam circulation is used, and in the greater part of the building automatic control of the heating is provided for by the Johnson thermostatic system. All radiators in public and guests' rooms are located in pockets or recesses beneath the windows or in walls, and are covered with metal gratings or screens of ornamental designs. All steam risers in all parts of the building are run in special pipe shafts, which are covered by furring and service connections to radiators made under the floor, in order to conceal all portions of the system.

For the supply of low-pressure steam to the radiators, there are 53 sets of vertical risers which extend from the distributing mains on the ceiling of the fourth basement to the top of the building. These risers are of 3 and 4-in. pipe, each being rigidly anchored to the steel frame at the fifth and sixteenth floors, with expansion loops at the twelfth floor. A feature of the risers and connections has been the use of easy bends at all offsets and turns where possible, in order to avoid fittings.

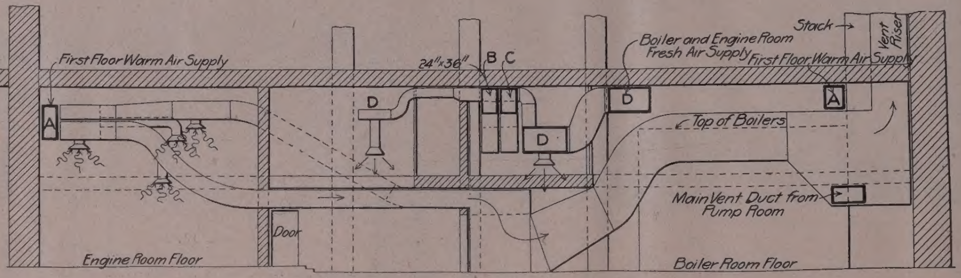
On each of the 18 typical bedroom floors there are 74 radiators, there being one under every window or group of windows. In most cases a single column American radiator has been used, although in some cases where larger surfaces are required, the double-column type is used. The amount of radiation allotted to each room was calculated on the British thermal unit basis, and thus varies widely with different rooms, depending on the thickness of outside walls, amounts of window glass, exterior exposure, etc. As referred to the cubic contents of the rooms, it varies from 1 sq. ft. per 100 cu. ft. up to 1 sq. ft. per 30 cu. ft., averaging about 1 sq. ft. to 60 cu. ft. This refers to floors between the fifth and fourteenth inclusive, rooms on floors above the fourteenth having about 10 per cent. more radiation, while those below the fifth floor have approximately 10 per cent. less. The system has been designed approximately 20 per cent. greater in capacity than would have been installed without the vacuum return system, the guarantee required for the system being to maintain the building at a temperature of 70° Fahr. in zero weather, with only one pound of back pressure at the engines.

A special heating equipment has been provided for the large window areas upon the 42nd St. front of the lobby to counteract the cooling effect of the glass. Sidewalk lights are used for daylight lighting of the grill room of the restaurant, which is located beneath the Park Ave. sidewalk, and beneath these are hung horizontal heating coils, each consisting of two or three lines of 1¼-in. pipe, which encircles the light at its edge, in such a manner as not to obstruct the light. The skylights at the foot of the light and ventilation courts, which afford daylight illumination in the palm room and corridors of the main floor, are similarly provided with coils hung horizontally along their edges. These coils are proportioned according to the conditions imposed by the light, and thus vary widely in amount of surface per unit of area of glass, the purpose of the coil being as much for the melting of snow off the glass in winter as for counteracting the cooling effect of the glass. All of these horizontal coils have hung beneath them strongly-built drip pans, of 22 oz. copper, which extend the full length of the pipe and are provided with drip pipes leading to drains to remove condensation and possible leakage.

Steam is supplied to the risers by a distribution system connecting with the exhaust piping at the muffler tank in the boiler room. This tank is the Utility combined exhaust steam muffler and grease extractor, built by the Standard Steam Specialty Co., New York, and serves the purpose of removing entrained lubricating oil from the exhaust before it enters the heating system or the atmospheric relief riser; it is located in the 16-in. exhaust steam line between the branch connection to the feed-water heater and the back-pressure valve leading to the atmospheric riser. As this main passes through the boiler room the live steam connections are made to it, one a 6-in. connection, with two Kieley reducing valves in series, from the main 16-in. high-pressure header and the other a 5-in. connection with a gate and angle throttle valve, for hand operation in case the reducing valves are out of service. The heating main branches in the boiler room, an 8-in. line extending to the west side of the basement to supply a portion of the risers in that section, an 8-in. branch to the east side for a number of risers, and a third of 12-in. pipe into the fourth basement level, a mezzanine off the power plant section, for the north side of the house. These branches, as well as the drop legs of all the vertical risers, are drained by a system of return piping which discharges directly by gravity into the feed-water heater through a U water seal. This line has ¾-in. connections at the bases of the risers which connect into mains of increasing size, entering the heater as a 3-in. line.

The steam circulation is that usual in the Webster system, the return pipes connecting to thermostatic relief valves on all radiators and heating coils, the vacuum pumps in the engine room keeping the system free from water of condensation. The pumps are 8x14x16-in. Worthington brass-mounted duplex pumps, which are in duplicate, either being capable of maintaining a vacuum of 5 to 10 in. in the return lines. The latter are arranged in the form of return risers paralleling the supply risers, with similar methods of support and provisions for expansion in the pipe shafts. The return risers vary in size from 1½ to 2½-in. pipe, connecting in the basement to a gathering system of return mains which increase to a 5-in. line at the pump-suction connections. The pumps discharge into an expansion tank on the ceiling, in which entrained air and vapor are separated, from which the condensation feeds to the heater by gravity as required. This tank is a steel cylinder 24 in. in diameter and 8 ft. long, and has a 5-in. vapor line which unites with the vapor line from the blow-off tank for a vent to the roof.

All radiation above the ground floor and in the public portions of the basement, as well as all tempering coils of the fresh air supply systems, are automatically controlled by the Johnson system of temperature regulation. The installation is of unusual size, with 743 thermostats operating the diaphragm valves by which the flow of steam to the radiators is controlled. Of the latter 787 were used for the control of 1,105 radiators and 3 tempering coils, each of the latter having two diaphragm valves each. The thermostats used in the guests' rooms are what is known as the "hotel type," in which the usual mercurial thermometer is omitted and an attachment added by which the occupant may easily set the thermostat to cut off steam from the radiator entirely or to operate it at various rates of condensation, which are obtainable by adjusting a pointer over a scale graduated to the corresponding temperatures. The compressed air for the system is supplied by two small steam-driven compressors in the pump section of the engine room. These are Worthington duplex compressors, each having 4x4x4-in. cylinders, and are controlled from the air pressure in the system by an automatic governor which cuts off the steam supply to the compressors when the air pressure reaches 20 lb. The distribution system involves a storage tank and supply mains of galvanized iron piping with brass fittings, having branches to all of the diaphragm valves.


First Floor Warm Air Supply
A
D
24"x36"
B
C
D
Boiler and Engine Room Fresh Air Supply
D
Stack
Vent Riser
First Floor Warm Air Supply
A
Top of Boilers
Main Vent Duct from Pump Room
Door
Engine Room Floor
Boiler Room Floor

Section XX through Fourth and Fifth Basement Levels, Showing Ductwork.

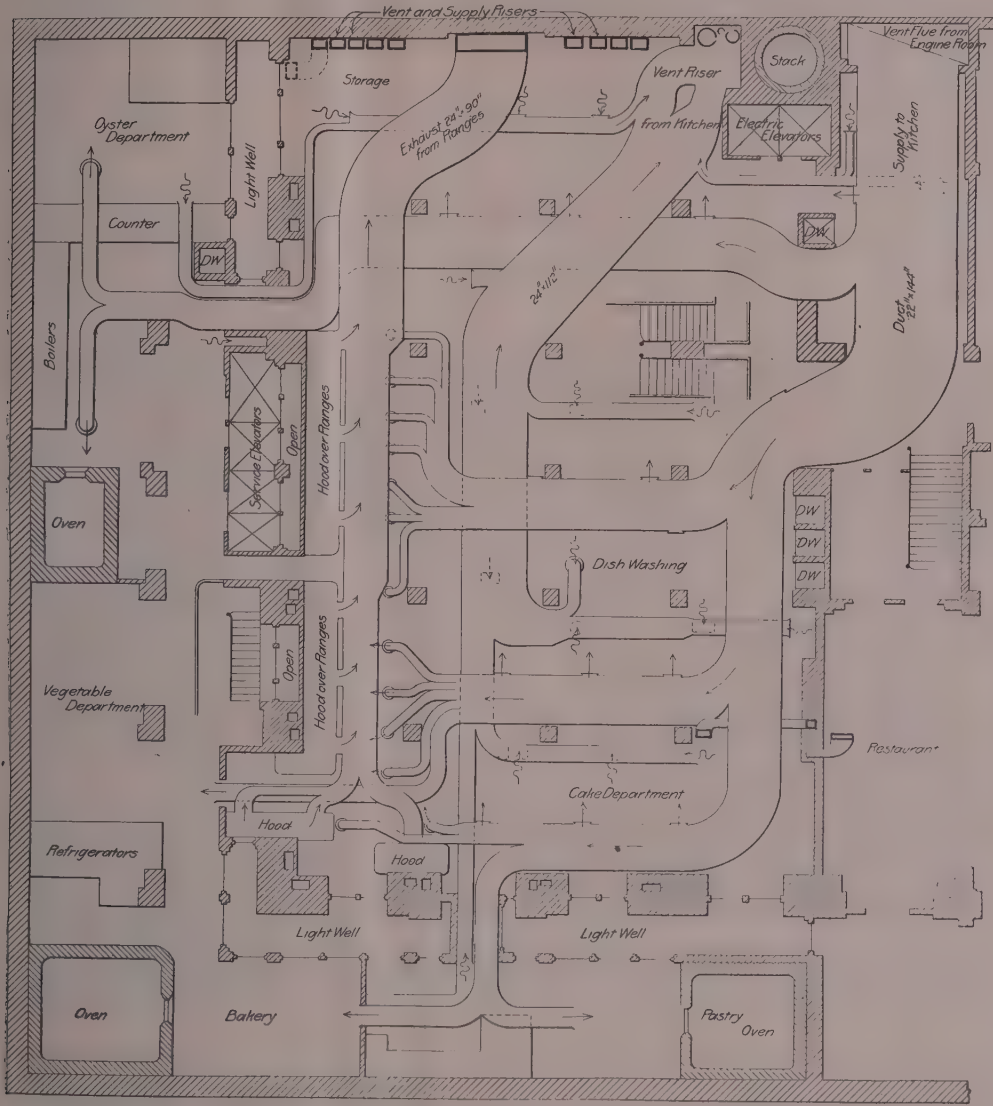
Ventilation System.—The ventilating apparatus in the building is interesting owing to the peculiar conditions imposed by the extensive subsurface quarters, which required fresh-air supply in addition to the ventilating provisions. The installation provides for a fresh cold-air supply to the boiler room, engine room and ice-machine room in the fifth basement; a tempered fresh air supply to the kitchens and laundries; a fresh warm-air supply for the café, servants' dining-rooms, and other rooms in the basements, for the entire main floor and its mezzanine and for a banquet room on the parlor floor; and exhaust ventilation for all of these rooms, and from all toilet and bath rooms throughout the building. The exhaust fans and blowers required for this service are located on the roof and in the fourth basement level, the mezzanine floor off the engine and boiler rooms, which afforded much too little space for a convenient and easily accessible installation; the arrangement of apparatus in these confined quarters is an unusual example of duct construction.

The supply systems which furnish fresh air to the subsurface floors and the public portions of the hotel on the first three floors have their equipments of plenum fans and heating coils for tempering, in the fourth basement at the 42d St. side, from which delivery ducts lead to points of outlet. The fresh air supply is taken at two fresh-air intake ducts at the rear of the building which rise to intake monitors in the base of the light and ventilation courts, at a point opposite the second floor level. These ducts have 128 sq. ft. of cross-sectional area and an unobstructed rise of 90 ft. to the screened outlets in the monitors. At the fourth basement level they open out into an intake and settling chamber, 68 ft. long, in which is located a large filter for cleansing the air drawn into the systems, beyond the filter being the fans.

The air filters are of cheese cloth, having a large number of cheesecloth-covered frames mounted in zig-zag order in the filter chamber, the total amount of surface of the filtering medium offered being 3,500 sq. ft. This filtering area bears a ratio to the cross-sectional area of the intake ducts of about 25 to 1, which reduces the velocity of flow through the cloth to a point where satisfactory filtering is possible. There are 116 of the cheesecloth frames, each 3x10 ft. in size, of light wooden construction and equipped with fittings for clamping tightly to the supporting structural steel framework. A novel idea is to be introduced in the operation of the filters in that the usual duplicate set of filtering frames has not been provided for the purpose of replacing those withdrawn for cleaning. The cheesecloth will here be cleaned by the vacuum cleaner system, which has been installed for general cleaning purposes in the building and will be referred to later in the article. The standard floor-renovator type of nozzle, such as is used for carpets and rugs, will be used here, as most applicable to the broad expanse of filtering cloth. This expedient will permit rapid, effective and dustless cleaning of the filters, and obviate the necessity of removing the screens and maintaining an extra set.

There are four distinct fresh-air supply systems, the blowers for which are so located that their inlet openings form a part of the wall of the above-mentioned intake and settling chamber. One of the systems, marked *A* in the drawing, supplies tempered air to the lobby, palm room, main dining rooms, and the banquet room upon the parlor floor. The second system, marked *B*, supplies the café, restaurant, servants' dining rooms, barber shop, etc., in the upper basements; while the kitchen and laundry air supplied from a third blower, marked *C*. The fourth equipment, marked *D* in the plan, supplies cold fresh air to the boiler, engine, pump and auxiliary rooms in the lower basement levels, where the heat given off from the machinery is amply sufficient for heating purposes. Systems *A*, *B* and *D*, have, on account of their size, two blowers each, driven in tandem from a single direct-connected motor; system *C* has a single fan. Each double blower equipment consists of two 6-ft. Sturtevant fans and the single equipment an 8-ft. Sturtevant fan, all of the full-housed type, with top horizontal outlets. The blowers are all mounted on wooden foundations with sheets of cork between the beams and the steel framing to prevent the transmission of vibration through the building. Systems *A, B* and *C* are driven by 20-h.-p. C. & C. slow-speed electric motors, while fan *D* is connected to a 25-h.-p. motor of similar make; these motors are all connected up with flexible couplings and each has three variations of speed by field control.

Each of the systems, *A, B* and *C,* has tempering coils in the inlet casing of its blower next to the air filters. The heaters are of the corrugated sectional-base type, each composed of five 6-ft. two-row sections, 12 ft. long, built up of 1-in. pipe, the total heating surface amounting in each case to the equivalent of 5,025 ft. of 1-in. pipe. The five sections are controlled in two groups, one of two sections and the other of three, by Johnson thermostats, located in the delivery duct from the fans served; the thermostats have different settings, the smaller group opening at a higher temperature than the other, while the larger group cuts in only when the smaller is incapable of sufficiently heating the air delivered. Each tempering coil is fed from the low-pressure heating mains by a 6-in. branch with 5 and 4-in. branches to the two groups of sections, which have the Johnson diaphragm valves; the individual connections to each section are of 2½-in. pipe, while the drainage connections to the Webster traps are ¾-in.



Arrangement of Supply and Ventilating Ducts in the Kitchen.

The duct work for the supply systems is shown in a plan of the fourth basement floor. System *A*, supplying the main and parlor floors, is the most important, and is of interest for the use of relay heaters in certain branches for superheating the air delivered through them. The two fans of this system have discharge openings 42 in. square connecting with a common duct 32x87 in. in section, which leads to the 28 service uptakes, which aggregate approximately 58 sq. ft. in sectional area. Two of them, which lead to register openings alongside the main doorway of the lobby entrance, are fitted with relay heating coils which may be used in severe cold weather to superheat the air delivered at this point where excessive amounts of cold air will inevitably be let in through the doorways. These relay coils are not controlled by the Johnson system, being cut in only during severe weather in winter.

System *B* also has two plenum fans, each with a discharge opening 42 in. square, which are joined to a common delivery duct, 32x120 in. in section. This leads to 18 service uptakes with an aggregate sectional area of approximately 44 sq. ft. System *C,* which is operated by the single 8-ft. fan, has a single delivery duct 4 ft. square which leads directly to the kitchen to supply the extensive system of distribution ducts for the fresh-air supply there, a few small branches being taken off on the fan floor level for supplying the wine room and five uptakes to the laundry, which aggregate about 13 ft. in total sectional area. The system in the kitchen is carried on the ceiling, the main duct changing in shape after leaving the uptake to a section 22x144 in., for economy of headroom. This main has four large branches, each of 8 to 9 sq. ft. section, leading to important outlet points in the vicinity of the ranges, kettles, boilers and bakery. Flexible outlet nozzles have been placed behind the station of each cook at the ranges to furnish the necessary cool air blast on the back of his neck or head, which is required by them for continuous work of that nature in close proximity to excessive heat.

The cold-air supply system, *D,* delivers only to the boiler, engine, pump and machinery rooms of the fourth and fifth basement floors, where additional heating is unnecessary. The two plenum fans of this system, each with a discharge opening 42 in. square, deliver through a common duct, 24x90 in. in cross section. This has a 14x64-in. branch downtake leading below to supply the pump room, while the main duct passes to five 16-in. circular outlets above the firing floor in the boiler room, and six 12-in. circular outlets above the pump section of the engine room. The purpose of the latter is to supply fresh air to the engine room, opposite a number of exhaust vents. All of these boiler and engine room outlets have flexible nozzles to permit the fresh air blast to be directed wherever needed.

The duct work required for the four supply systems, as well as for the exhaust connections to the vent flues, is necessarily very complicated, both on account of the limited space available for this equipment and the large sizes of many of the ducts, practically the entire fourth basement level, or engine-room mezzanine, being devoted to blower equipments and ducts. The largest duct is the main delivery of system *B*, 32x90 in. in size. In the fan room much ingenuity was displayed in installing the large number of flues of large size without interference, and even at that many changes of section and size were necessary in order to obtain the necessary clearances. The ducts are of heavy galvanized iron throughout, those of 30 in. or more in width built of No. 20 gauge, while those of 12-in. width and over are of No. 22 gauge. They are heavily braced and carefully hung for rigidity, and the tempered-air systems and all the exhaust system are covered with asbestos air-cell covering, 1 in. thick, wired on and bound with No. 10 canvas; the covering was installed by the T. M. Valleau Co., New York.

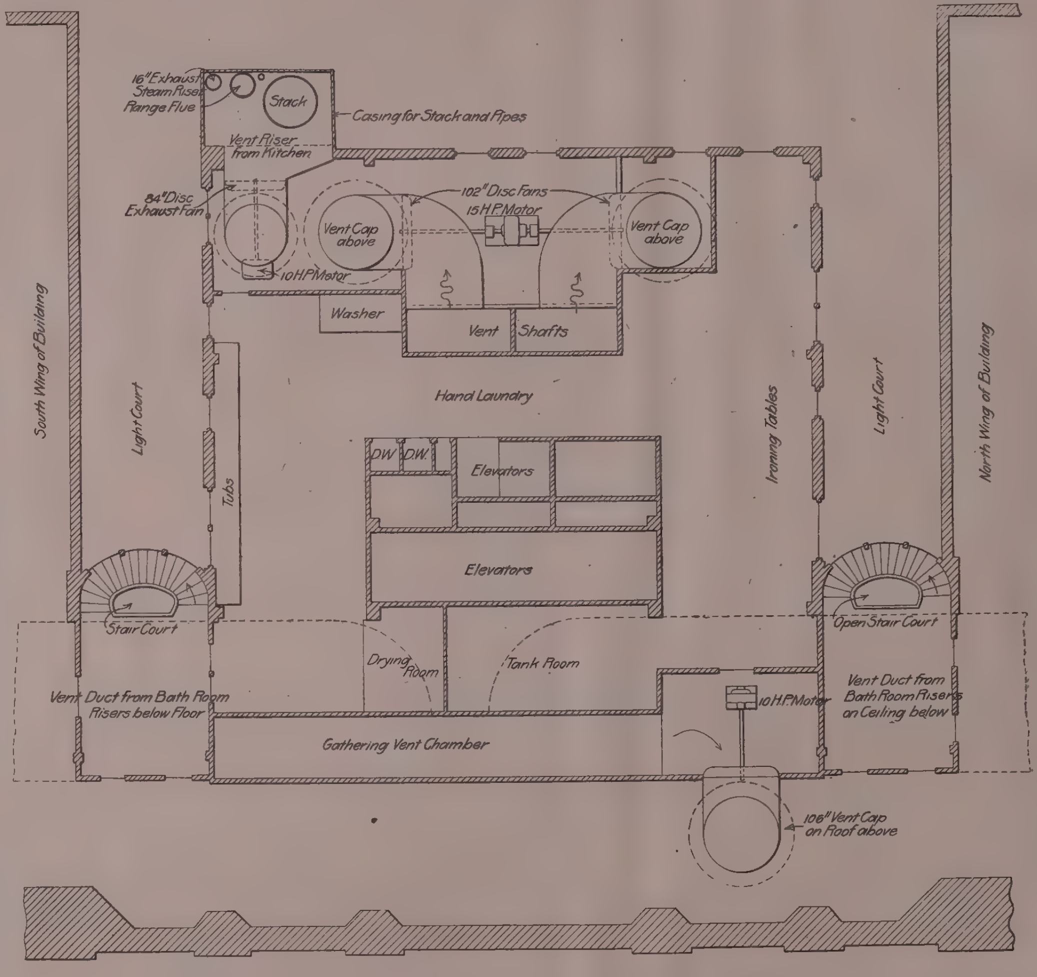
The exhaust systems for ventilation are even more comprehensive than those for fresh air, as in addition to removing foul air from all of the rooms served by the supply systems, exhaust ventilation from the toilet and bath rooms is also provided. The exhaust systems all have their discharge outlets on the roof, at which point the exhaust fans are located. These have been installed of sufficient capacity in relation to their duct systems to change the air in all of the basement and public rooms at least six times per hour; for the heated machinery departments and also in the laundry and kitchen, the exhaust systems have been designed to make eight changes of the air per hour. It is to be noted that the exhaust systems for the kitchen and laundry, especially, have been designed fully 25 per cent. in excess of their fresh air supply systems in capacity, so that there will always be a tendency toward inflow through doors, windows, etc., to these departments, which will effectually prevent the communication of odors therefrom to other parts of the hotel.

The exhaust system for the engine and pump rooms consists of a 54x56-in. vent riser flue at the rear adjacent to the smoke stack flue, which rises to the disc exhaust fans on the roof and into which is connected at the bottom a 24x48-in. branch from the pump room and a 33x65-in. branch from the engine room. The former has five 12-in. circular exhaust openings in the pump room and two 16-in. inlets in the ice-machine room, while the latter has seventeen 12-in. circular openings. All of these exhaust openings are located on opposite sides of their respective rooms from the fresh air supply outlets, in order to effect a general circulation of air throughout the room. The laundry exhaust system is of large capacity for thorough ventilation of this department, owing to the particular nature of the work. For this purpose one of the large vent risers, 4x12 ft. in cross section, at the rear of the buildings, paralleling the fresh air shafts, is exclusively used, to which is connected a main gathering flue, 20x144 in. in cross section. This divides into six large branches leading to the various inlet openings, which have been distributed with care in order to cover thoroughly the entire laundry department and the adjacent storerooms and toilets on the same floor; one of the main branches also serves the servants' dining room upon the floor above. The 42nd St. end of the laundry floor, which is devoted to a number of storerooms for trunks and for general storage purposes, contains a system of ducts that serves the barber shop, manicure rooms, subway corridor in the subbasement and the general toilet rooms and restaurant in the first basement. This ventilation system is operated through a second 4x12-ft. vent riser and a main gathering flue of the same size as that for the laundry system.

The exhaust system for the kitchen is similar to that for the laundry in capacity and completeness of distribution of exhaust openings. For a riser flue the rectanguar sheet-metal casing surrounding the smoke stack, exhaust steam riser to the roof and kitchen range smoke flue, has been utilized. This casing is a steel plate enclosure, 8x15 ft., in section, which was primarily intended to conceal the group of flues and pipes rising through the light and ventilation court to the roof, but which serves very effectively also as a vent flue, the cross-sectional area available for this purpose, exclusive of the pipes and flues, being 65 sq. ft. Into the lower extension of this pipe flue are connected two distinct systems of gathering exhaust ducts in the kitchen, one 22x90 in. in size, exhausting from the hoods above the ranges, vegetable boilers and cookers, and the other, 22x112 in. in section, gathering from exhaust openings distributed frequently throughout the balance of the kitchen for general ventilation. The kitchen exhaust flues are made of No. 10 sheet iron for their entire length.

The ventilation of the lobby on the main floor and its mezzanine is effected partly by the palm room vents and partly by the general ventilation of the corridors and elevator shafts into which there are large open doorways; while the main dining room, the parlors and the banquet hall are ventilated through a number of vent ducts with distributed exhaust openings, which lead down to the exhaust connections on the third basement level. The palm room is surmounted by a domed ceiling of highly ornamental design, the space above and surrounding it forming a part of the exhaust riser system from the basement ventilation systems. The three large 4x12-ft. vent risers at the rear of the basement floors, which conduct the exhaust from the engine room, laundry and café systems to the deck house exhaust fans, are connected by a cross-over duct at the base of the light courts to a large vent shaft, 5x24 ft. in section, within the central wing of the upper structure back of the passenger elevators, for which cross-over the vacant space above the dome is utilized. The exhaust openings for the palm room and lobby ventilation consist of a number of vents opening through the base of the dome into a ring collecting duct, 20 in. square, which discharges directly into the cross-over flue immediately above in this space.

The ventilation of the guests' rooms is effected through vents in the bath rooms, when these are provided; otherwise the rooms are without ventilation other than that available through outside windows, with which every room in the hotel is provided. All baths and toilets on the nineteen sleeping-room floors have exhaust connections with a ventilation system operated by one of the exhaust fans in the deck house, the ventilation of the sleeping rooms being effected through louvre openings in the doors leading into the bath rooms. The connections to the bath rooms are small vent shafts, so distributed throughout the floor plan as to make direct connections by means of register openings through a partition possible in almost all cases. The shafts vary from 24x30 in. to 24x123 in. There are five of them in each of the outside wings of the building, four in the central wing and five on the front side of the house. The exhaust openings into the bath rooms are through 8x12-in. registers, which have deflectors behind them in their riser shafts, opening upward to prevent back-drafts into the rooms. These vent risers all discharge into a system of large gathering ducts which are carried above the ceiling of the servants' dormitory on the twenty-first floor, the arrangement of the risers close to the corridors being such that direct connections to the gathering duct were possible in nearly all cases.



Part Plan of Deck House upon the Roof, Containing the Exhaust Fans.

As above stated, the exhaust fan equipments are located in the deck house on the roof of the building, the fans delivering directly to the discharge caps in the deck-house roof above them. There are four of the exhaust fans, of the Blackman disk type, three with 102-in. wheels operating at 225 r.p.m. and one 84 in. in diameter operating at 250 r.p.m. Two of the large fans are set back to back and are driven from a single motor to exhaust from the 5x24-ft. vent shaft in the central wing of the building. The other large fan exhausts from the gathering ducts of the bath-room vent system, while the 84-in. fan serves as an auxiliary to the natural draft in the casing surrounding the smoke flue and other pipes, which ordinarily is effective in exhausting from the kitchen ventilation system. The fans have horizontal shafts direct connected to C. & C. electric motors, each of which has three speeds by field regulation. The motor driving the two large fans on the single shaft is of 15-h.-p. capacity, while that for the other large fan is of 13 h.-p. and that for the 84-in. fan of 10 h.-p. The air-discharge caps or hoods on each of the fan outlets are of 24-oz. sheet copper, weather-proofed.

An interesting auxiliary ventilation is to be noted in the provision of induced draft in the fireplace flues to effect positive drafts therein under unfavorable conditions of the weather. There are seven of these flues, 24 in. square, in the outer walls of the building, which serve gas logs in the fire places of the more important guests' rooms, and in these have been installed steam coils arranged for operation with high-pressure steam, which will, when heated, create strong drafts in them, with resulting removal of fumes from the gas logs and increased ventilation of the rooms. Each coil contains about 50 ft. of 1¼-in. brass pipe and is located near the top of the flue. They are supplied with steam from the high-pressure riser which is brought up to the deck house to supply the auxiliary laundry located therein, the connections to the coils being made upon the ceiling of the dormitory floor.

A novel feature of the exhaust duct construction for the ventilation systems is the installation in all exhaust openings of self-closing dampers controlled by fusible links, so that if fire should occur in any of the rooms served, the exhaust openings will close on the entrance of flame or excessive heat from the fire. These dampers are of special design worked out by the ventilating engineers, and are so weighted as to always close tightly when not held open in some manner. They are normally held open by the fusible links, located on the inlet side, so as to melt quickly with an excessive rise in temperature and allow the damper to close. The result of this provision is that in case of fire in any room the tendency will be for it to be smothered out, rather than augmented and enlarged by the ventilation exhaust. In an actual test to which the system has been subjected, these dampers closed promptly and the fire merely burned itself out locally.

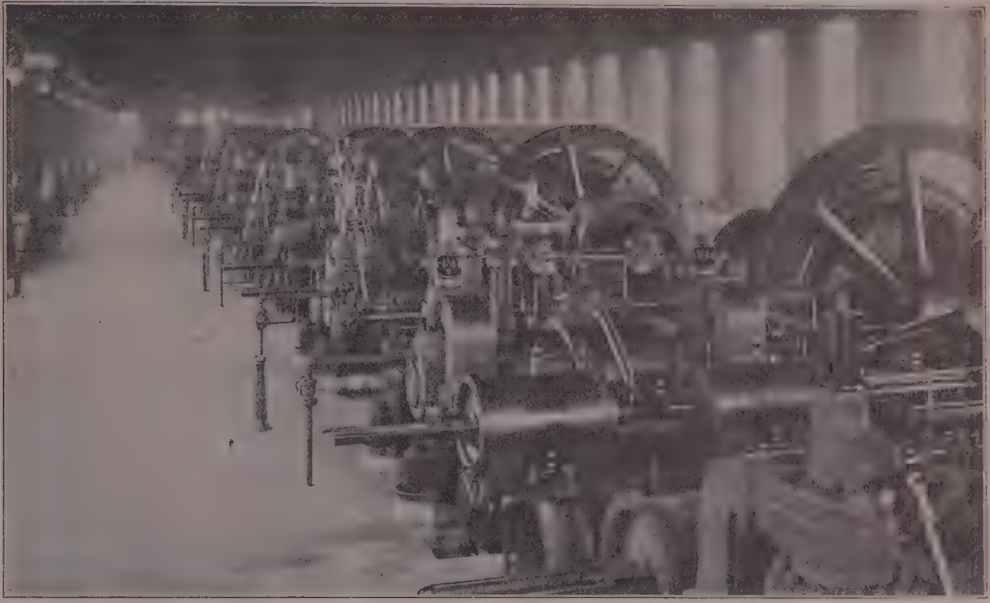
As previously stated, the heating and ventilating engineers and contractors for the Hotel Belmont were Messrs. Baker, Smith & Co., New York, who have installed the complete equipment to which reference has been made in the preceding article.

(To be Continued.)

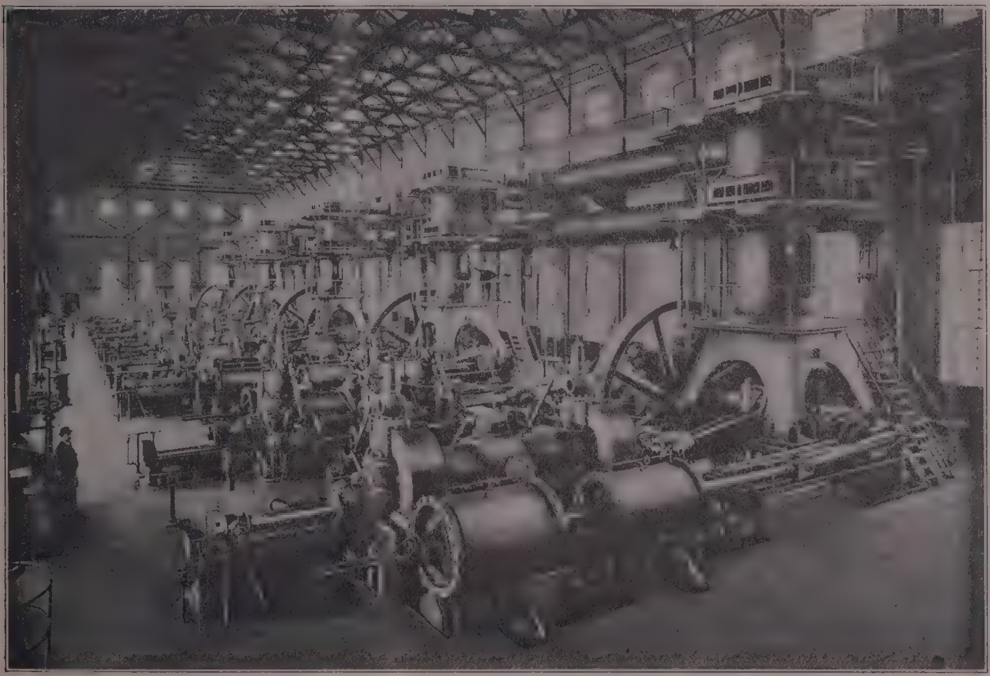
Modern Gas Engine Power Plants.

By Franz Koester.

One of the most remarkable successes in the engineering industry of late years is the introduction of the modern gas engine. This does not mean the gas engine of some ten years ago, but the gas engine equal in size and capacity to that of modern steam driven prime movers, which has, beyond doubt, a much greater efficiency than the latter. With the appearance of this prime mover a new competitor of the steam engine and turbine enters the field, although its existence in power plants to-day is not so noticeable in this country as in Europe, especially on the Continent. This is not to be wondered at, particularly in Germany and Belgium, where the scarcity of water power and the exorbitant price of coal necessary for the production of the electricity of to-day's requirement practically forced the engineers to develop a substitute for the steam engine. Continental Europe has, since the middle of the nineties, been carrying on costly experiments with the larger types of gas engine and has encountered numerous difficulties, as the construction of these units was at first on lines similar to existing gas engines only on a larger scale. Only after radical changes in the design, in general as well as in detail, were better desults obtained. On account of the failure in the first attempts to produce gas engines of a large type, certain discredit was forced upon the smaller and older types also, this, however, being completely dispelled after several years of thorough experiments; and this was especially true after the modern gas engine proved to be more economical and simpler in operation than any existing steam prime mover.



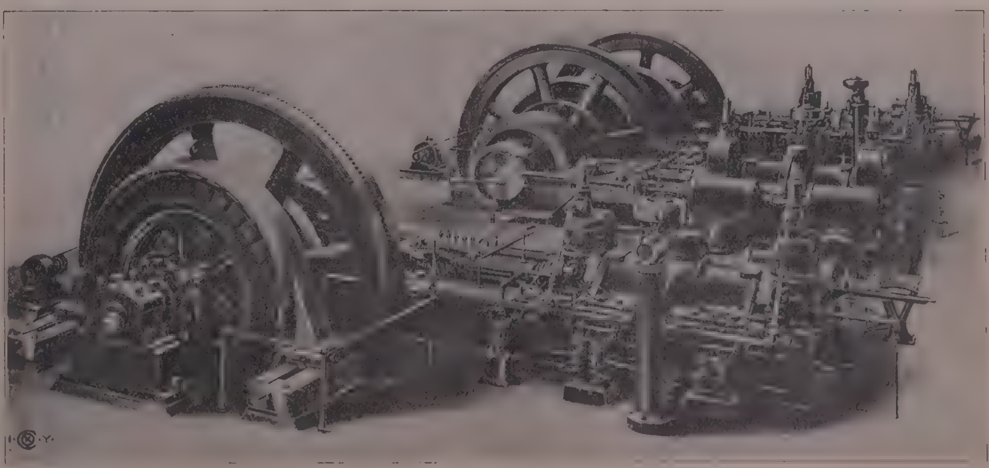
View in Power Plant of Lackawanna Steel Company, Buffalo.



View in Blower House of Lackawanna Steel Company, Buffalo.

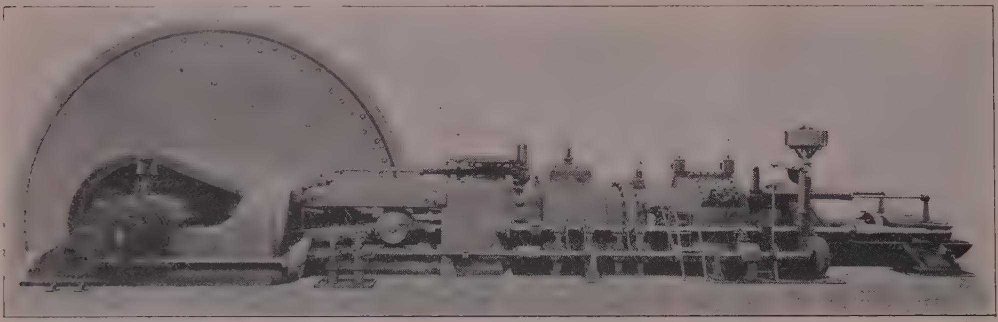
Since then, some four or five years ago, the modern gas engine has been rapidly put on the market and taken up by many different leading manufacturers on the Continent, and it is at present competing with the best of the large size steam engines. It will probably be not so very long before it will generally take its place in the foremost position in power plant practice, especially as these engines are capable of very efficient operation with poor quality of gas, such as blast furnace gas. It will therefore be seen that central electric power stations may be economically operated in conjunction with blast furnaces and foundries, supplying light and power to the surrounding industrial community as well as to the manufacturers themselves. As there are plants of this character giving off vast quantities of this gas and as in modern practice, high potential alternating current makes feasible long transmission lines, it will be seen that a great field is open for enormous sized central stations employing this type of prime mover. Not only has the gas engine found its way into the blast furnace works, where it utilizes the gas previously wasted, but it has to-day also acquired a position of no small importance in coal mines.

As is the case with nearly all new inventions, the gas engine encountered many difficulties. Here the trouble arose in cleaning the coke oven gases of by-products, such as tar, benzol and ammonia, which is of great importance before allowing it to enter the cylinder. This difficulty has, however, been successfully overcome to-day. Whatever gas may be employed, illuminating, blast furnace, producer or coke oven gas, it is most important to thoroughly purify it, before supplying



De La Vergne Engines Running on Natural Gas.

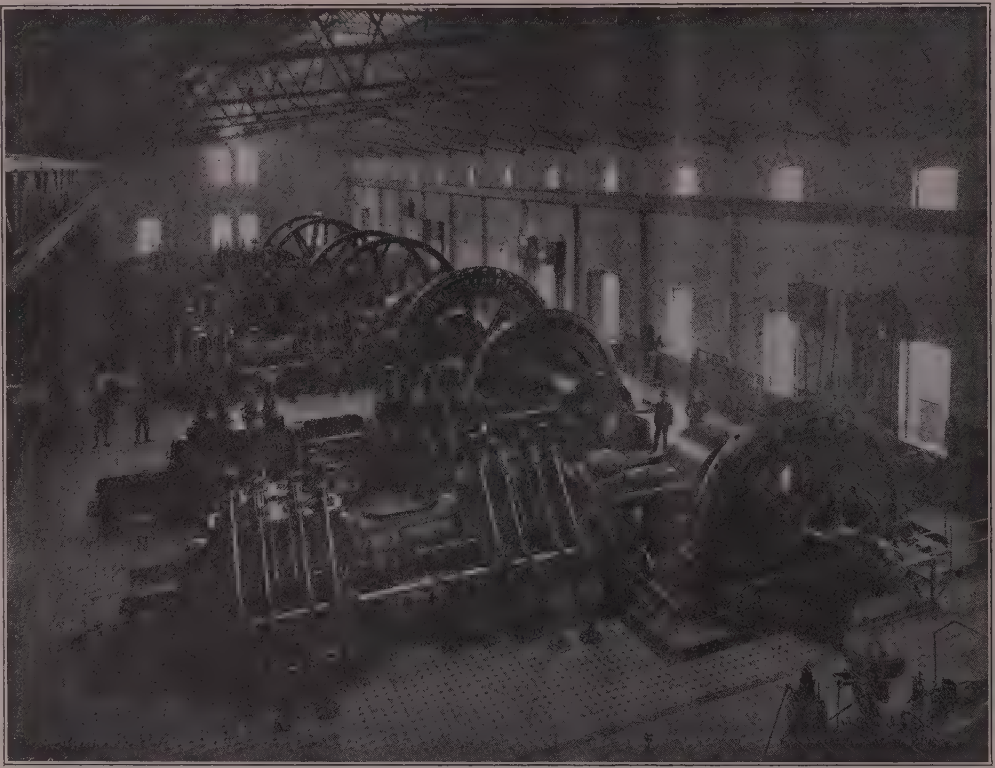
it to the engine, to assure a greater economy in operation and to reduce the frequency of cleaning to a minimum. A well equipped purifying plant or system installed in connection with the gas engine station is a paying investment.



Single-Cylinder 1800-Horse-Power Gas Engine Built by A. Borsig.

Considering the economy and simplicity of the operation of the gas engine, it will probably not be long before the sight of large gas-engine electric stations operating under railway and lighting conditions, will be a common one. Under ordinary circumstances, city plants are limited to the use of illuminating, suction or producer gas, and it must be remembered that such plants, having large storage tanks and purifying systems, do not add to the beauty of the surroundings. These, however, are unimportant questions in American practice, as frequently proven. Very different is it in Europe, where the steam power plants, although of artistic design, are shifted from the city to a suburb.

The large gas engine suitable for present power plant practice is, as previously stated, of an entirely different design from that of the older common small gas engine. The former are not as simple in construction as the latter and approach more nearly the fine appearance of the well and thoroughly constructed Continental horizontal poppet valve steam engine. Some of the accompanying illustrations give sufficient proof of the excellence of design of these engines, as used on the Continent, where the greatest credit is due for the successful development of the gas engine represented in modern practice. Of course it would be well to have a gas engine with as few links and levers as possible, if the same economical operating results could be thus obtained. The writer, however, wishes to state here that an attempt to thus simplify the construction would result in a failure, similar to the Corliss valve engines operating in America with a steam consumption, under favorable conditions, of from 13 to 15 lb. as compared to the Continental engine in which only 9 to 10 lb. are consumed per indicated horse-power hour. Comparative tests will probably prove this in the near future. There ought to be no fear for the so-called complicated engine, nor fear of the incompetent operator. The Continent does not find any difficulty with the operators, as they prefer to run a machine which would overtax the ability of an ordinary mechanic. Of course instruction is required for the operation of every new invention and the wages of these men must be adjusted according to their capacity. The Continent gives every day notable examples of the economy of prime movers, whether steam or gas engines, and it is to be hoped that these good examples will be followed. It is certainly not the operator's fault to be unable to run the "modern" engine, but rather the fault of the manufacturer for not giving him the opportunity of developing his ability. However the gas engine may be designed, the main intent is to produce a horse-power as cheaply as possible and for less than can be done with a steam engine, and that a good gas engine will do this has frequently been proved abroad as well as in certain instances in this country.



Gas Engine Power Station of the Rombacher Iron Works.

Gas Engine and Blower, Rombacher Iron Works.

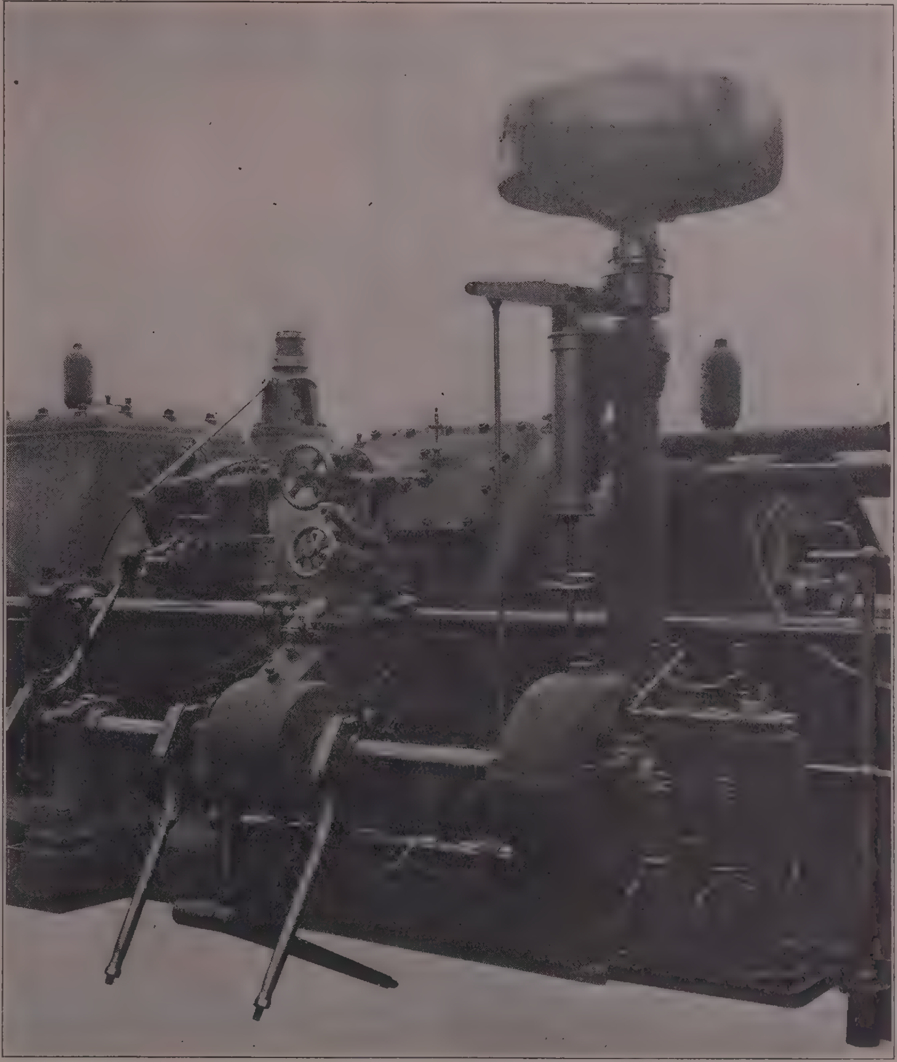
The first of the accompanying illustrations shows the interior of the blast furnace plant of the Lackawanna Steel Co. at Buffalo. These units are of 1,000 h.-p. capacity each. The gas engines are of the Koerting two-cycle type, as manufactured to-day in this country by the De La Vergne Co. of New York City. Upon the shafts are mounted three-phase alternating and direct-current generators. A second illustration shows the very same type of engines in the same works, operating also with blast furnace gas and running blower engines. There are sixteen of these engines installed, of 2,000 h.-p. capacity each. Engines designed for the use of natural gas are shown in a third illustration, representing three 600-h.-p. two-cylinder, double-acting De La Vergne-Koerting engines. It is often claimed, in this country, that gas engine generators could not be operated in parallel, but this plant is an example of stations where this is accomplished very successfully.

Reviewing the European plants we find many equipped with the Nuremberg gas engine, one of the foremost in Europe, as designed and installed by the Maschinenbaugesellschaft of Nuremberg, Bavaria. Some of the following illustrations represent this make and the writer would call attention to the thoroughness of the construction, especially the governor. In a plant at the Rombacher Iron Works, in Germany, continuous-current generators are mounted upon the shafts of the two first units and on the third an alternator, while the other units are provided with fly wheels.

Gas Engine Plant of the Micheville Steel Company.

These latter units operate blast engines on the other side of the column line, not shown in the illustration, whose pistons are mounted on the extended piston rods of the gas engines. A complete view of one of these units is given in the fifth illustration. Comparing the fourth and fifth illustrations, a marked contrast in the appearance of the two sides of the same engine will be observed. In the former view is seen the controlling mechanism, representing the part of the engine upon which greatly depends the efficiency and economy, as in a steam engine; while the latter shows the bulky construction commonly found in iron works. This engine unit is of enormous length, due to the tandem arrangement of the cylinders, which was overcome in the Koerting engines in the Lackawanna plant by using vertical blower engines, while the gas engine is horizontal. The Nuremberg engines are of 950 h.-p. each, making 80 r. p. m., and operating with blast furnace gas. It will be noticed that for the capacity these engines cover a large floor area, but the sixth illustration will serve to show the compact construction of the very same type and make of engine when not connected to a blower. It represents two 1,100-h.-p. blast furnace gas engines erected at the existing plant of the Société Anonyme des Aciéries de Micheville, at Micheville, France. It is understood that the rights of the Nuremberg gas engine, which is of the four-cycle type, in the United States, Canada and Mexico are controlled by the Allis-Chalmers Co., of Milwaukee.

As is the case with all successful engineering inventions, the manufacture of the gas engine has been taken up by many prominent concerns, here as well as abroad, and especially in Germany, where every step in the development of the gas engine since the start has been watched with the keenest interest. Consequently in the latter country, there are to-day a number of types on the market, one of the most successful being the Oechelhaeuser, built by the well-known firm of A. Borsig, Berlin-Tegel. This engine is of the two-cycle type. One of the accompanying cuts represents a single-cylinder 1,800-h.-p. gas engine of this make capable of carrying an overload for a short time up to 2,000 h.-p. It is claimed that this particular type requires a small diameter of cylinders, and as the construction requires a very light bed plate it will be noticed that the engine is very low, resulting in easy supervision. The entire weight of this engine, including the flywheel, is 325 long tons. The last illustration gives a view of the good workmanship on the governing mechanism of this engine, which is commonly found on the Continent. These engines, as well as those previously described, of course are built for different sorts of gas, and sizes up to 4,000 h.-p. and higher are to-day under course of construction.



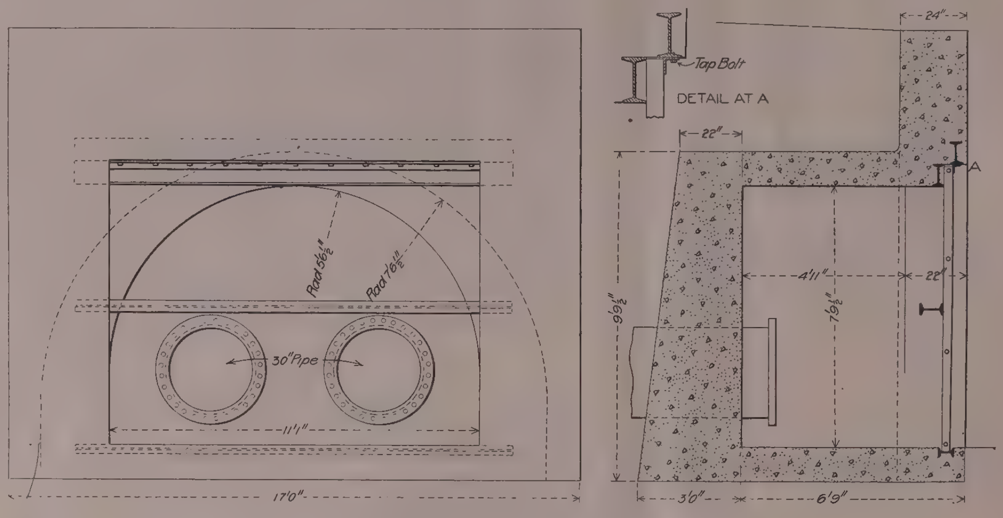
Governing Mechanism of the Borsig Gas Engine.

All gas engines require more or less careful inspection and frequent cleaning, the latter depending upon the character of the gas. Mechanical starters are employed wherever the parts are of such heavy construction as to make difficult the turning by hand. These are usually operated by electricity of compressed air.

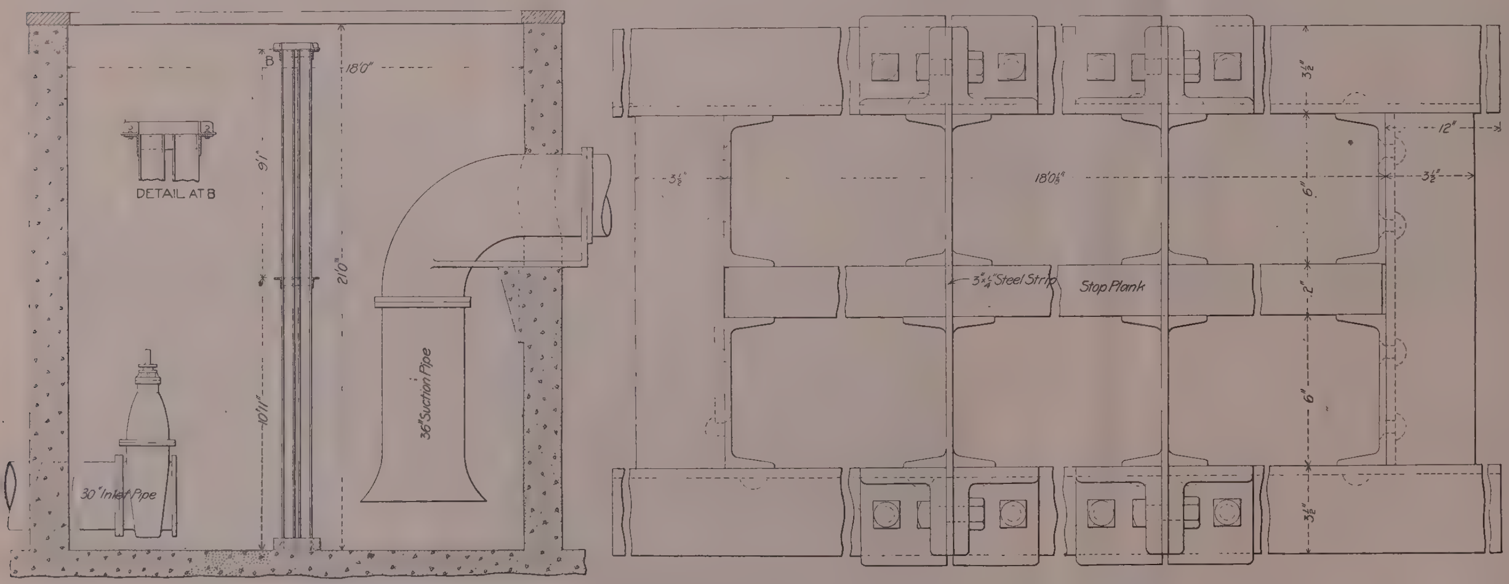
Suction Well for the New Reading Pumping Engine.

Extensive improvements have recently been made to the water works system of Reading, Pa., necessitating among other things the construction of a large suction well for a new vertical triple-expansion 15,000,000-gal. Allis-Chalmers pumping engine. This well is built entirely of concrete and is worthy of note chiefly on account of the simplicity of the screen rack built in it and of the arrangement of the suction pipe for the pump. The well is built just outside of the pumping station, and is 18 ft. in diameter and 21 ft. deep. A part of the water supply of Reading is drawn from a creek adjacent to the well and enters the latter through two 30-in. valved inlet pipes on one side. The stream carries floating débris, which has to be completely screened out. This material is removed by two rows of screens placed on the diameter of the well at right-angles to the axes of the inlet pipes.

The screens are supported in a rack framework built up of standard structural-steel angles, I-beams and channels. Each row of screens is divided in 3 lengths across the well. Four vertical ways, in which the three sections slide, are provided in each row, one at each end of the latter and one between the adjacent ends of the sections. The end ways are 6-in. steel channels and the other two are 6-in. I-beams, the framework for both rows of screens being built together. The I-beams are placed with their webs transverse to the line of the screens and with the adjacent flanges of those in the two rows 2 in. apart. The lower ends of the beams are tied together by angles and imbedded in 6 in. of concrete. The space between the adjacent flanges of the I-beams is maintained by two cast-iron blocks to each pair of beams, one at the bottom and one 7.5 ft. above the bottom. The beams are held vertically by four 3.5x5-in. horizontal longitudinal angles, with their ends imbedded in the concrete walls of the well. Two of these angles are 10 ft. 11 in. above the bottom, one on each side of the framework, and the other two are at the top, also one on each side of the frame. The long legs of the angles are riveted to the outer flanges of the I-beams, the rivets being countersunk on the inside of the flanges so as not to offer any obstruction to the movement of the screens in the ways. A ¼x3-in. steel strip is placed transversely on edge over the top of each pair of I-beams and in line with the webs of the latter. The ends of this strip are riveted to the legs of short pieces of angles which are riveted to the top longitudinal angles on each side of the frame. The I-beams are also attached to a longitudinal 3.5x3.5-in. angle placed on each side of the framework at the bottom and imbedded in concrete.



Front and Transverse Sectional Elevations of Intake.



Transverse Sectional Elevation of Suction Well; Detail Plan of Supports for Screens in Suction Well.

The depth of water in the well does not usually exceed 7.5 ft., so screens will be required only to that height. Above that height 2-in. stop planks are placed in the space between the adjacent flanges of the I-beams and the channels in the two rows. These planks are held up by the cast-iron spacing blocks.

The framework for the screen racks required a nominal expenditure, and as it includes no wood it is believed that it will be easily maintained. The steelwork has been painted black and on the whole presents a neat appearance. The rack has proved satisfactory in service, as the screens are easily removed and replaced.

The inlet pipes to the suction well extend into a concrete box intake in the creek. One side of this intake is open and the water enters through a vertical rack, placed over the opening, made up of ½x3-in. iron strips bolted together. The rack is arranged as shown in the accompanying illustration so it may be removed with little difficulty. The opening in the side of the intake is 8 ft. 5.5 in. high and 11 ft. 1 in. wide. A 5-in. I-beam is placed longitudinally and with its web horizontal in the concrete at the bottom of the opening, its upper flange being flush with the surface of the concrete. An 8-in. longitudinal I-beam is placed with its web vertical and so that the inside of the rack at the top rests against its lower flange. A 7-in. longitudinal I-beam is imbedded in the concrete over the opening, its lower flange being just flush with the lower side of the concrete. The rack is set with its bottom on the web of the I-beam in the lower side of the opening and with its top against the I-beam on the inside at the top of the opening. It is held in place by a 3x3 in. angle top bolted to the outer I-beam at the top and can be removed readily by removing this angle, which is above the normal water level. An 8-in. longitudinal I-beam is placed horizontally on the inside of the rack at the center, with its ends imbedded in the concrete at the ends of the opening, and the screen is braced against it.

The 36-in. pump suction pipe in the well is entirely self-supporting. It enters the well horizontally, with its center line 14 ft. 2 in. above the bottom of the latter. The concrete walls of the well are normally 18 in. thick, but this thickness was increased on the under side of the pipe to 2.5 ft. The section of the pipe extending through the wall is a special half-bend with a heavy bracket cast on the lower side of its horizontal leg and in connection with the regular flange. This bracket rests on and is imbedded in the concrete. It carries the half-bend and a piece of straight pipe, 8 ft. long, placed vertically and bolted to the flange on the end of the vertical leg of the half-bend. No particular care was exercised in laying the concrete of the wall around the horizontal leg of the pipe and its supporting bracket, but no difficulty has been experienced from cracking. The lower end of the suction pipe has a bell-mouth which together with the general arrangement of the remainder of the suction is considered to reduce the entrance and friction losses to a minimum.

The construction work was carried on under the direction of Mr. Emil L. Nuebling, superintendent of the water works. Mr. Chas. A. Hague, of New York, is the consulting engineer for the improvements that have been undertaken and designed the well and intake described here.

The Foundations of the Campanile in Venice have been considerably enlarged prior to the reconstruction of the shaft, as explained in an article by Mr. F. Hopkinson Smith in this journal on Dec. 3, 1904. Nearly 3,100 larch piles averaging 8 in. in diameter and 12 to 13 ft. long have been driven in the bottom of a trench surrounding the old masonry. These have had their tops covered with a timber grillage and concrete, thus enlarging the old base so that a total load of about 16,000 tons can be carried, if a unit bearing capacity of 4.82 tons per square foot is adopted.

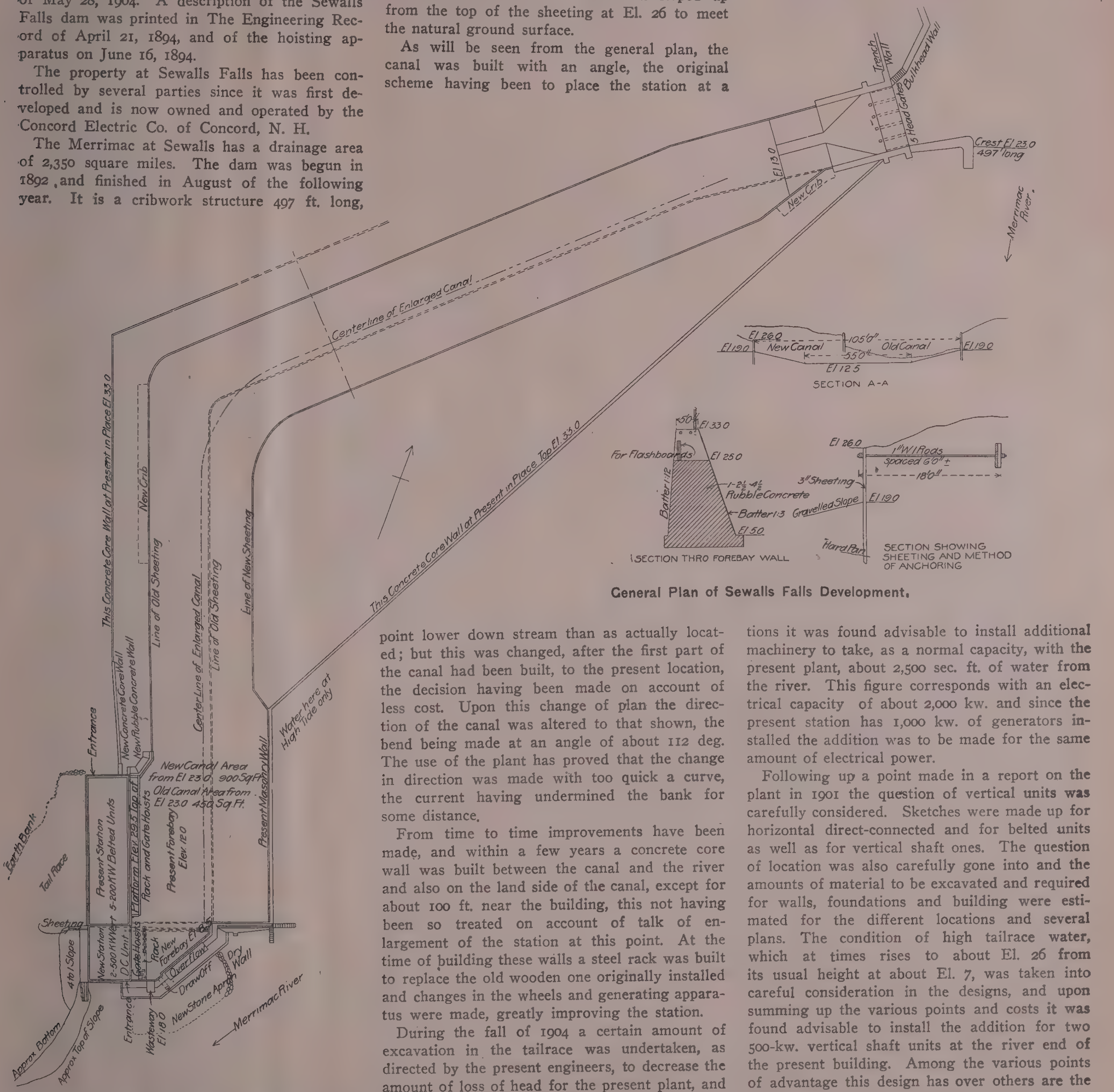
Additional Power Development at Sewalls Falls, N. H.

By Edw. B. Richardson.

Sewalls Falls is situated on the Merrimac river 4.5 miles above Concord, N. H., and about 9 miles above the Garvins Falls plant of the Manchester Traction, Light & Power Co. of Manchester, N. H. The development at this latter point was described in The Engineering Record of May 28, 1904. A description of the Sewalls Falls dam was printed in The Engineering Record of April 21, 1894, and of the hoisting apparatus on June 16, 1894.

The property at Sewalls Falls has been controlled by several parties since it was first developed and is now owned and operated by the Concord Electric Co. of Concord, N. H.

The Merrimac at Sewalls has a drainage area of 2,350 square miles. The dam was begun in 1892, and finished in August of the following year. It is a cribwork structure 497 ft. long, with planked aprons protected by iron plates. The abutments, wing walls and canal head-gate works are of rubble stone masonry. The elevation of these is from 13 to 16 ft. above the crest of the dam.



General Plan of Sewalls Falls Development.

There has been obtainable up to the present time a maximum of 15 ft. fall, but with the changes now under way it is planned to obtain 16.5 to 17 ft., the gain being made at times of low water by decreased loss of head in both canal and tailrace.

The original canal, about 1,200 ft. long, 11 ft. deep and 59 ft. wide at El. 23, (the crest of the dam), with a cross section of 450 square ft., was dug in soft sand, the bottom going down to hardpan, or to the stratum of coarse gravel above, at the center for a width of about 12 ft., and from this level having a comparatively flat slope to El. 19 at the planked sides. The earth above this slope was held in place by hemlock sheeting spiked and bolted to a hemlock cribwork buried in the bank which sloped up from the top of the sheeting at El. 26 to meet the natural ground surface.

As will be seen from the general plan, the canal was built with an angle, the original scheme having been to place the station at a point lower down stream than as actually located; but this was changed, after the first part of the canal had been built, to the present location, the decision having been made on account of less cost. Upon this change of plan the direction of the canal was altered to that shown, the bend being made at an angle of about 112 deg. The use of the plant has proved that the change in direction was made with too quick a curve, the current having undermined the bank for some distance.

From time to time improvements have been made, and within a few years a concrete core wall was built between the canal and the river and also on the land side of the canal, except for about 100 ft. near the building, this not having been so treated on account of talk of enlargement of the station at this point. At the time of building these walls a steel rack was built to replace the old wooden one originally installed and changes in the wheels and generating apparatus were made, greatly improving the station.

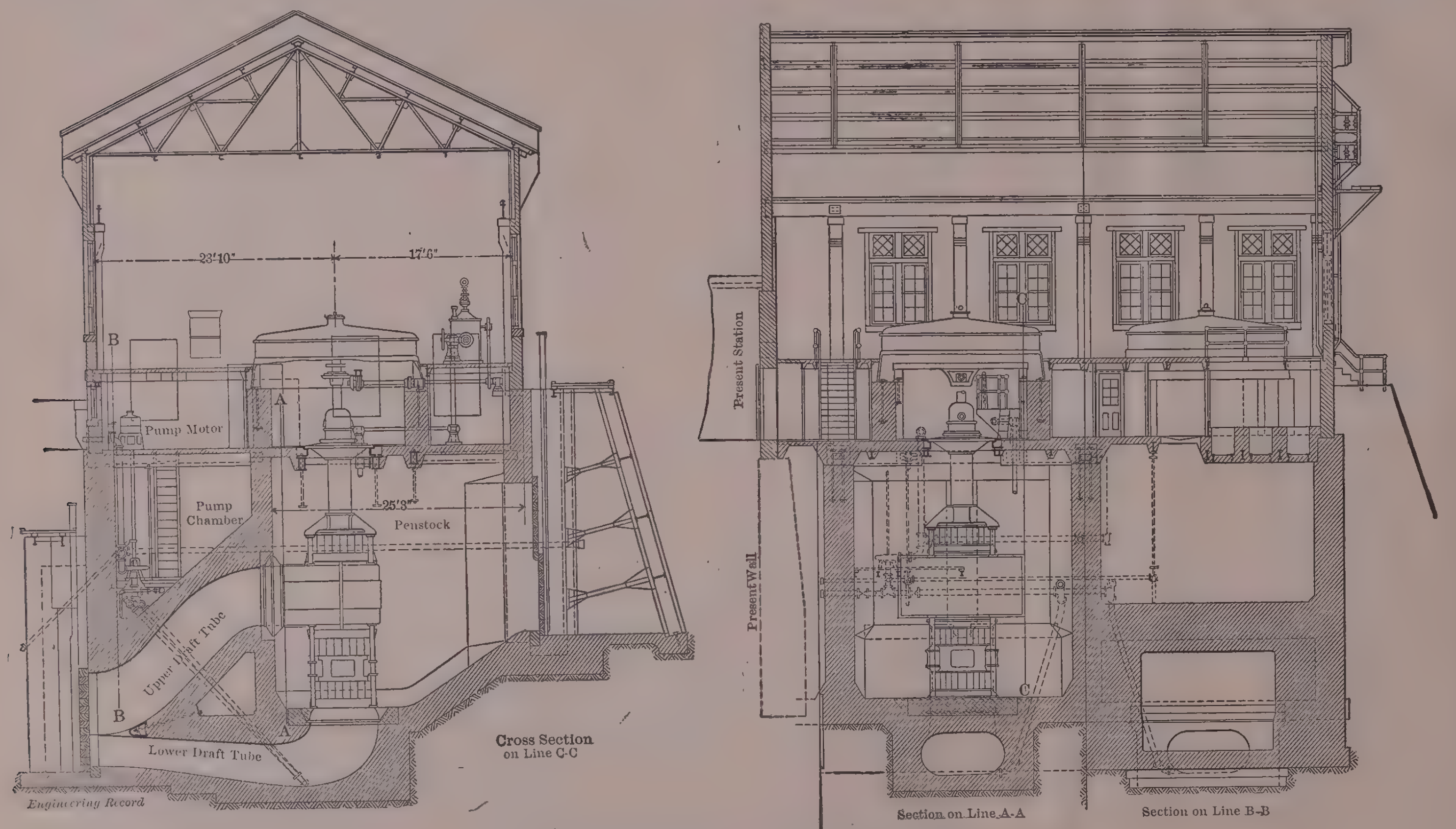
During the fall of 1904 a certain amount of excavation in the tailrace was undertaken, as directed by the present engineers, to decrease the amount of loss of head for the present plant, and although cold weather put a stop to the work an appreciable change for the better was noted. During this work it developed that the best method of handling the excavation was by driving iron pipe through the water into the hard clay gravel and exploding dynamite in each pipe after it had reached the desired depth. By breaking up the bottom in this manner the clay could be removed by dredging or by a scoop.

The owners decided during the winter of 1904-05 to increase the capacity of the plant in order to supply the Boston & Maine Railroad with additional power for the street railway system which it operates in the neighborhood of Concord as well as for other increases of load. The present engineers, who were quite familiar with the conditions at the property, were called upon to draw plans and specifications for the various details of a complete addition to the existing plant.

Upon making a searching study of the conditions it was found advisable to install additional machinery to take, as a normal capacity, with the present plant, about 2,500 sec. ft. of water from the river. This figure corresponds with an electrical capacity of about 2,000 kw. and since the present station has 1,000 kw. of generators installed the addition was to be made for the same amount of electrical power.

Following up a point made in a report on the plant in 1901 the question of vertical units was carefully considered. Sketches were made up for horizontal direct-connected and for belted units as well as for vertical shaft ones. The question of location was also carefully gone into and the amounts of material to be excavated and required for walls, foundations and building were estimated for the different locations and several plans. The condition of high tailrace water, which at times rises to about El. 26 from its usual height at about El. 7, was taken into careful consideration in the designs, and upon summing up the various points and costs it was found advisable to install the addition for two 500-kw. vertical shaft units at the river end of the present building. Among the various points of advantage this design has over others are the following: very little tailrace excavation, the station being near the lower end of the old one and at the river edge; the old overflow wall at the end of the canal was in poor condition and of extremely light construction, requiring to be rebuilt unless done away with; less excavation for the building proper was necessary; less shutting down of present plant was probable; the cost of building and foundations was less, and the generators would be above the highest tailwater, thus obviating expensive waterproofing. This design made the total cost due to greater cost of machinery but a few thousand dollars more than that with alternative plans, and the additional expense was fully justified by advantages gained.

It would seem from the careful estimates and various plans made for the above plant that engineers in this country would do well, in forwarding the interests of their clients, to look carefully into vertical direct-connected units of a type similar to that adopted in the present case, where they have to meet similar conditions of low head and high backwater, as well as for more usual conditions. Although this type of unit has not been much seen in this country, it has been used very successfully abroad and judging from the details of the machinery, heaviness of parts, care with which the draft tubes are worked out in order to change velocity head into statical head, most of our builders can learn considerable from European practice. Parties planning hydro-electric developments should also consider carefully the advisability of increasing the investment somewhat by the purchase of turbines built for the conditions of each case as against the installation of wheels built to sell. The above considerations are the main ones which determined the engineers to advise and the owners to adopt the design of plant as it is at present being installed. A description of the addition as it will be when completed is given in the remainder of this article.



Cross-Sections of New Power Building at Sewalls Falls

The Canal and Tailrace.—The new canal follows the lines of the old mainly in order to decrease the amount of excavation. The canal was enlarged on the river or interior-angle side, making the sharp bend previously mentioned much easier. This work was done in a dry canal, the company having found that a net saving could be made on the canal work if the present plant was closed down, power being purchased elsewhere during such a period, thus allowing the contractor to do the excavation with men and teams instead of by dredging.

The silt in the bottom of the old canal was removed, the old sheeting and cribwork torn out on one side and the necessary excavation done to increase the area from 450 to 900 sq. ft., this increased section being obtained by a bottom width of 55 ft. and a surface width of 105 ft., the type of section remaining the same.

The new sheeting of tongue and groove hard pine 3 in. thick was placed in position in a trench dug into the stratum of gravel overlying the hardpan, and then forced down to bottom. A waling piece was placed against the sheeting near the bottom as a guide where necessary. Near the top another heavy wale was placed and bored for anchor rods every 6 ft. The rods were of 1-in. galvanized iron about 16 ft. long. The bank ends were anchored to a 3-in. hard pine plank fence through 6-in. by 8-in. hemlock posts well buried in a trench, as indicated on the general plan. After backfilling and grading as necessary, the nuts on the canal end of the rods were drawn up against cast iron washers.

The sheeting along the opposite side of the canal was repaired as thought advisable, that at the bend together with the crib being entirely replaced, as the latter had been undermined, letting the bank slump considerably. At the upper corner of the station on the canal a concrete wall was built making this point secure. The core wall was also extended to meet the wing cut-off wall at the end of the present building.

During the shut-down the plant was cleaned up and overhauled, the racks being cleaned and painted. The bottom of the rack for a height of from 1 to 7 ft. was found to be choked with leaves and débris, the sand and silt having piled up so as to close the openings very effectually. At the headgates, the old flooring in the canal was repaired and extended as was necessary to meet the new canal section.

The old overflow wall at the station end of the canal will be removed after the new station and forebay walls are completed sufficiently, but until such time it will be left in position as a cofferdam, making possible the use of the old canal.

During the period of shut-down for the above work an earth cofferdam was built across the tailrace below the addition and the work of excavating the tailrace and for the station foundations was carried on. This work was greatly hindered by several floods, so that when it was possible to use the canal the building foundations were not completed as was planned. This made necessary (upon the removal of the above dam) the construction of another cofferdam of the crib type about the building substructure on the tailrace side. This latter dam allowed the use of the tailrace, so that the present plant is now in operation.

It is expected that the loss of head in the enlarged canal will be 0.12 ft., that in the end entrance 0.20 ft., the velocity of water in the former being 2.67 ft. per second, and in the latter about 4 ft., although this will vary considerably at different points. The entire loss of head from above the head gates to the mouth of the tailrace will not be over 0.6 ft. under normal conditions.

The Station.—Upon studying the generator and turbine plans it became evident that a reinforced concrete foundation or substructure could be constructed of the requisite strength more cheaply than one with masonry walls. Considerable more excavation and ground area would be taken up by the latter type of construction to meet the varying conditions of water pressure which might be expected. The engineers are of the opinion that considerable concrete work is being done to-day with an extreme minimum amount of material and that for such work as power stations a certain mass is desirable although not absolutely necessary for strength. Because of this opinion the foundation walls were designed thicker than thought necessary by several ferro-concrete builders. The additional expense is not great, being chiefly in concrete, since the surface and strength of the forms are practically the same.

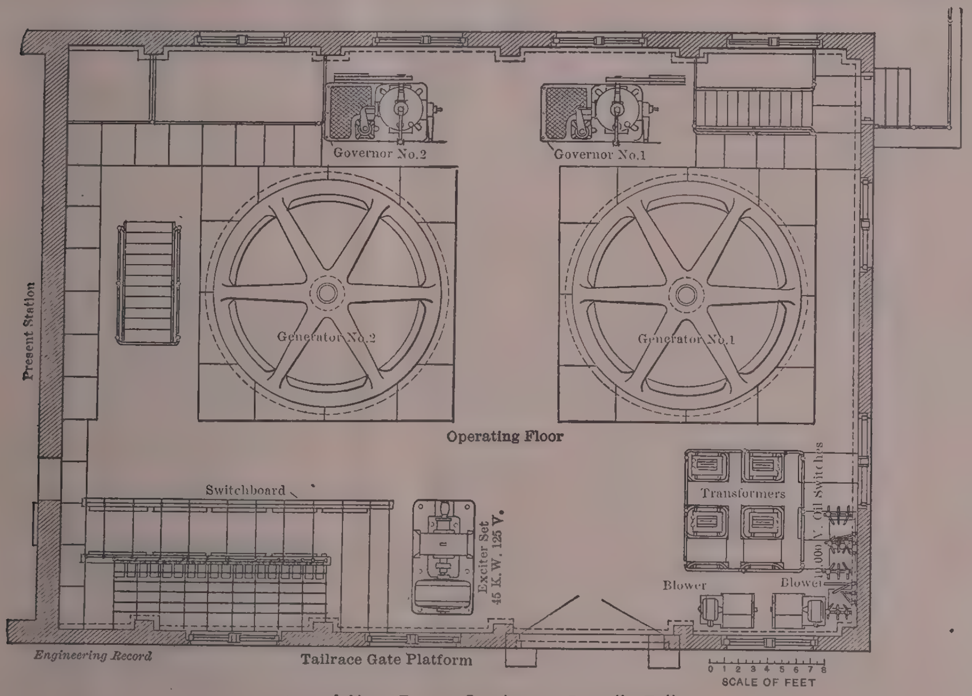
The design and principal dimensions of the station may be seen from the accompanying illustrations. Concrete throughout the work is of Portland cement, sand and crushed stone, in the proportion by volume of 1:2½:4½. Where there was a large mass without reinforcing rods rubble concrete was used, the large stones being well bedded in the above mixture. The forebay wall is of rubble, as are the tailrace building piers.

Special attention should be given to the careful design of the draft tubes, the idea being to obtain a uniform change in velocity of the water from the entrance to the exit, this change being obtained by a uniform change in area of successive sections throughout the length of the tubes.

The penstock gate openings afford ample area for the entering water so that the velocity, about 3 ft. per second, is low. The cross-section of the penstocks is much greater, the velocity of approach to the wheels being about 1.73 feet per second. For the outlet ends of the draft tubes the area gives a velocity of 4.73 ft., but slightly greater than that in the tailrace, which will have an approximate average velocity of 4.0 ft.

On the upper, or operating floor level are located the generators, although they are supported from the lower floor on sections of a concrete base above which is the heavy cast iron ring to which the stator is bolted. On this floor also are located the switchboard, exciter, governors, and blowers, the latter for the step-up transformers below. The construction of this floor is peculiar in that certain parts are of slate slabs resting on hard pine leveling strips, the remainder of the flooring being reinforced concrete with smooth mortar finish. These parts constucted of slate are about the generators, over part of the transformers and over the bulkheads in the lower floor. The reason for this design was that during times of dismantling or for repairs it would be necessary to have the flooring opened up and this construction with slate slabs and bolted connections for the structural support would afford a ready and convenient means of obtaining the necessary openings.

The lower floor is of much heavier construction, of reinforced concrete throughout. In this floor over each penstock is a large and heavy cast iron bulkhead of special design for gaining admittance to the space below. The cover of each bulkhead and the supporting frames are machined at surfaces of contact, the former being tap-bolted to the latter, the joint having a rubber gasket to make it water tight. Such a joint is necessary, as at times the water may rise above the level of this floor. Similar but much lighter bulkheads are provided for admittance to the chambers above the draft tubes.



Plan of New Power Station at Sewalls Falls.

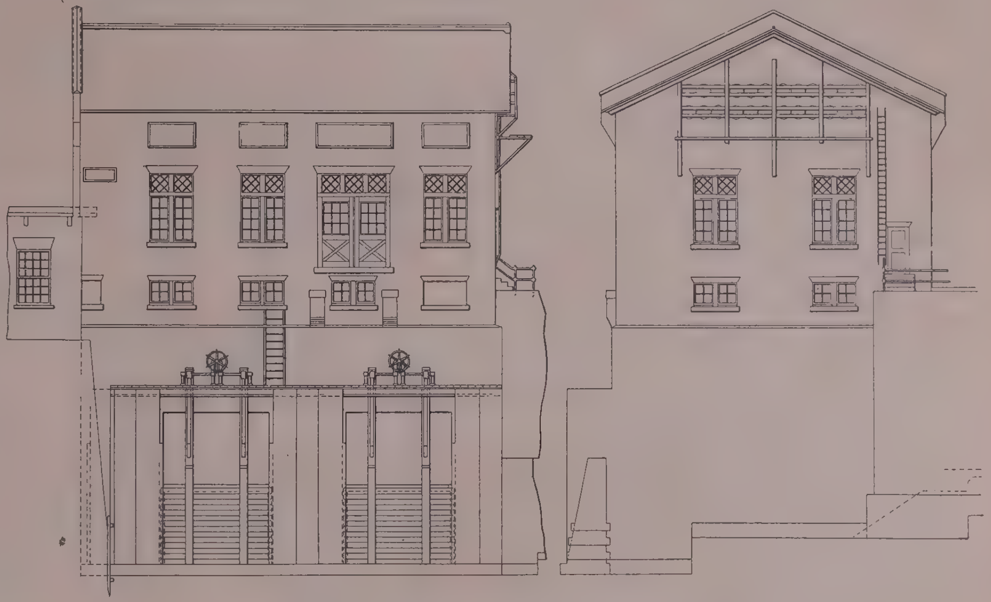
As mentioned, the generators are supported on circular concrete bases, each of which has four openings for admittance to the space enclosed. In this space is a heavy step-bearing, described later, and also a platform with steps for reaching the collector rings and brushes.

Connections between the governor and gate shafts are also made on this floor, the latter being near the floor and the governor power shafts near the ceiling.

In one corner are located the step-up transformers provided with ducts below and connections to the air shaft under the blowers overhead. A damper is provided for shutting off air from each set of transformers.

In the chamber under this floor and opposite No. 2 unit is placed a 5-in Worthington vertical shaft volute pump for emptying the draft tubes in a reasonable time. Suction connections are made to the low point of each set of tubes and provision is made for future additions. This pump is driven by a vertical-shaft induction motor located on the lower floor. The piping is made large with easy bends, the discharge being carried up above high tailwater and provided with a throttling valve to avoid overloading the motor when the pump has increased capacity due to operating under a head or a low suction lift.

Connection between the present station and the addition is made by a doorway at this level. By means of a ladder outside one of the windows, access to the draft tube gate platform is had. For reaching the forebay overflow and the penstock gate platform a door is provided from the operating floor. The machinery for the present building will be taken in through a temporary opening in the river end wall. A large door is provided on the tailrace side, it being the intention to build, in the future, a bridge across the tailrace opposite this opening.



West and South Elevations Showing Insulator Brackets.

The superstructure is of brick with pilastered walls. Between the pilasters are provided large windows to give ample light. The steel roof trusses, supporting a hard pine plank roof covered with slate, rest on built-up steel posts. At the base of each post is a plate bolted through the granite pilaster cap to the wall. On these plates and caps rest the crane track girders.

In the gable end of the station next the river are circular slate panels set in iron frames through which the transmission lines are carried. Outside the building are structural brackets designed to support strain insulators from which the wires will span the river, a distance of about 700 ft. These brackets are tied back through the building by the roof purlins and by channels between the lower members of the trusses. The method of taking care of the 24 transmission wires was quite a problem, the plan adopted being as simple as any and doing away with a separate structure or a wire tower.

The entire addition has been designed with the end in view of future extensions being made by the removal of part of the present plant, and for this reason the switchboard, pump, and some other parts have been placed as shown in order to be more central later.

The Rack.—The rack is built up on a structural steel frame resting on a reinforced concrete flooring and is braced back against the building substructure piers. The platform above is of hard pine plank and was necessarily placed at the height shown to support the gate apparatus. The gratings are of 4x5/16 in. flats spaced 1½ in. in the clear and made up in sections. The spacing rods are placed back of the center of the bars to allow the teeth of rakes to pass without catching. The spacers are cast iron washers and have a larger external diameter than could be obtained by using pipe of the size to fit the rods closely. This was done to brace the flats better and to avoid any chance of their being pushed into a position other than at 90 deg. with the rod. The pitch of the gratings is 1 in 3.84. The clips holding the gratings in position are arranged so that each section can be removed easily. In designing the rack it was considered advisable to make it of sufficient strength to act as a dam should anchor ice close up the openings and the water be drawn from behind. This same condition was considered in the design of the Garvins Falls rack and during last November it was called upon and did meet this very case. Although the likelihood of such a condition arising was possible but not probable, the consideration given this point proved its good judgment.

The Gates and Hoisting Apparatus.—When the original five canal head gates were installed they were fitted with excellent slides, guides, trucks and hoisting apparatus, all five gates being provided although hoists for only three were placed. These hoists, working only by hand, had been changed to operate by a belted motor. The remaining gates are now being fitted with hoists, and any gate may be operated by hand or through a friction clutch by a geared motor. This apparatus is of Rodney Hunt Machine Co. make. All the gates about the addition are built of selected Georgia hard pine and are provided with stems of similar wood.

The penstock gates, each closing an opening 15 ft. 6 in. by 7 ft. 6 in., are peculiar in design in that there are two for each penstock and each gate is a double-leaf one. This design was advisable on account of the large waterway desired, since even two openings would require a gate, if made with a single leaf, of unwieldy depth. The double leaf was further necessary to avoid placing the hoisting apparatus much higher and the shutting off of light from the station windows. Each gate is provided with a 16x22-in. cast iron filler gate which is operated by a hand wheel on a threaded gate shaft. The design of the wood gates is such that there can be no chance of the upper leaf, which is not fastened to any stems, dropping should ice hold it in its open position after the lower leaf is part way down. Links fastened in the gate stems catch on cast iron noses bolted to the upper leaf and hold the two leaves together until the upper half is in its closed position, when the link is lifted away from the hook by hand. Shafts of flat iron extend from the links up the stems and have a handle on their upper ends to provide a means of operating the links from the platform above. Heavy cast iron lugs are bolted to the upper leaf and project over the lower one. Upon hoisting the lower leaf, the upper will also be lifted.

The draft-tube gates cover an opening 9 ft. 6 in. high and 14 ft. wide. They are built of 10-in. timbers well bolted together and reinforced at top and bottom by 10-in. channels and at an intermediate point by a 10-in. I-beam. With such a width of opening and the pressure due to high tailwater, reinforcement of the gate was necessary.

All the gates for the station run on heavy cast iron slides built into the masonry. The slides and bolts were placed in the forms before the concrete was filled in.

In the forebay wall is a draw-off gate of 5-in. timber with double stems for drawing down the water in the canal to the bottom at El. 9.0 This opening is 4x6 ft. For ordinarily passing ice, driftwood and extra water, an overflow gate is provided. This gate is of 6-in. timbers 8 ft. 10 in. wide by 8 ft. 4 in. long and has double stems. The bottom of the opening is at El. 18.0 and extends up 8 ft. wide to the top of the wall. This gate is arranged to lower entirely below the opening and will be operated as a control valve, regulating, in conjunction with the canal head gates, the height of water in the canal.

All gates, except those otherwise mentioned, are operated by hand power, the apparatus being of various types furnished by S. Morgan Smith of York, Pa.

For a length of 50 ft., the top of the forebay wall is at El. 25 to serve as an overflow. A bridge is provided across this length at El. 33, the top of the wall. The bridge is supported on three structural steel horses, the canal side member of each horse being used in conjunction with intermediate posts, for the support of 2½-in. white pine flash boards, the top of which may be at El. 30.

The Turbines.—Each turbine has three 55-in. bronze runners of the Francis type mounted on a heavy vertical shaft hung on the step bearing previously mentioned. The machines were built by the Allis-Chalmers Co. according to the designs and patents of Escher-Wyss & Co. The shafts are held vertical by three metal guide bearings fed with oil from above.

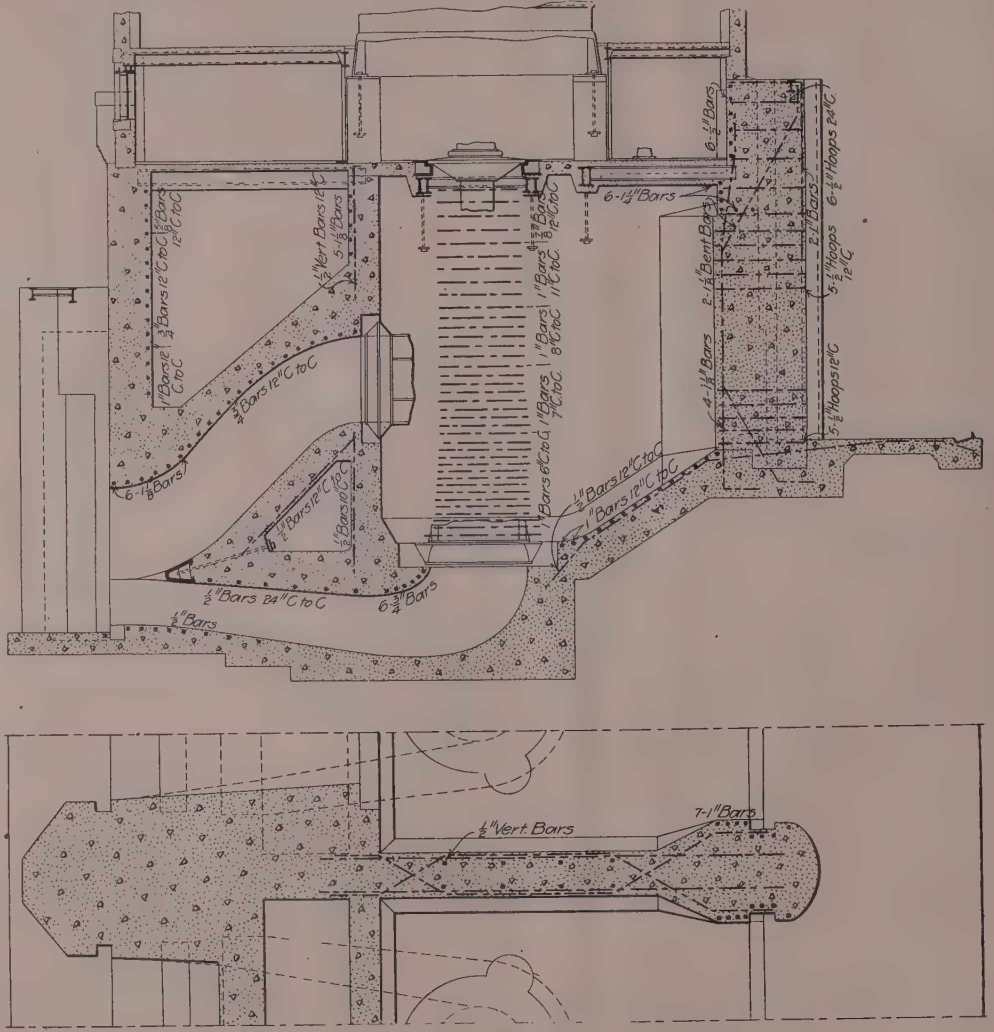


Diagram of Reinforcement in Division Wall of Station.

The gates are of the wicket pattern, operated by a ring and link connection to the control shafts, two in number. All three sets of gates operate together. Nuts, bolts, etc., where subject to removal or adjustment, are of bronze. The bearings mentioned above are supported from the casing, which is of heavy castings, and these in turn are supported one from another by four posts or columns formed as part of the castings themselves. The heavy T center casting is bolted to a heavy frame set in the wall at the entrance of the upper draft tubes, thus obviating all chances of vibration. All running parts, including the generator rotor, above are supported on a large thrust bearing located above the usual water level. Should the water rise above El. 28 in the penstocks a guide bearing and rubber gasket will act as cut-offs. The fixed member of the beaing proper rests in a removable cover set in a frame which is built into the floor and bolted to heavy I-beam girders spanning the penstocks. The bearing cover, as well as the bearing proper is removable, in order that the shafts and parts below may be removed by the crane. The bearing surfaces are of large area and are immersed in an oil reservoir of large size. At two opposite points in the cover of this bearing are eight holes closed with glass. A cooling coil is also provided, although it is anticipated that no undue heating will occur requiring water connections to be made. There is a heavy square thread on the main shaft, on which the running block of the bearing is locked. This thread provides for adjustments and wear take-up. The design of the turbines is such that when running the water exerts an upward pressure, thus reducing the weight on the bearing. This is accomplished by the use of revolving disks with water pressure below and partial vacuum or reduced pressure above.

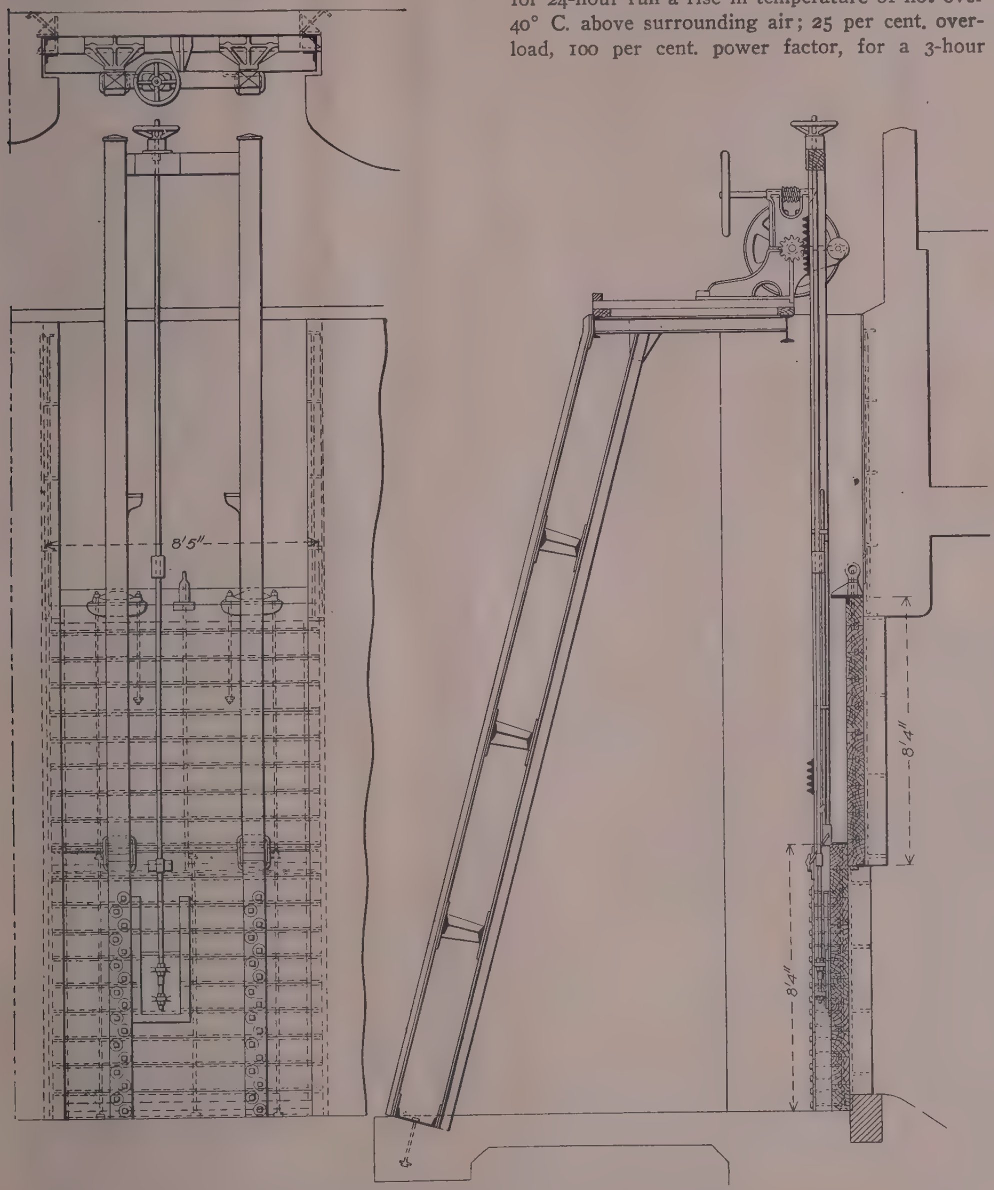
The builders guarantee the following operating results: Power: 16 ft. head, 900 b.h.p. at generators, with 620 cu. ft. per second; 12 ft. head, 625 b.h.p. at generators, with 650 cu. ft. per second; constant speed down to 12 ft. head.

Efficiency: Sixteen ft. working head, 100 r.p.m. or 5 per cent. above or below this speed; full gate, 78 per cent. or better; ¾ gate, 80 per cent. or better; ½ gate, 75 per cent. or better; 900 b.h.p., 80 per cent. or better; 700 b.h.p., 75 per cent. or better. Not over 12,000 ft.-lb. applied to governor shaft will be required to open and to close gates easily with the wheels operating.

Governors.—For each unit is provided a vertical mechanical governor made by the above company. These governors work with oil pressure, the pump for this is contained in the governor base and is driven from the wheel shafts through bevel gears, shafting and link belting. The machines are similar in type to the Niagara ones, but of improved design adapted to the needs of this plant. Each requires about 13 h.-p. for operation. The following results are guaranteed.

Variation from Normal Load.	Variation in Speed.
25%	Not exceeding 2% in 1.5 secs.
50%	Not exceeding 4% in 2 secs.
75%	Not exceeding 6% in 2.5 secs.
100%	Not exceeding 8% in 3 secs.

Generators and Auxiliaries.—The generators of the Bullock Elec. Mfg. Co. make are furnished by the Allis-Chalmers Co. under the same contract with the turbines and the governors.



Elevation and Section of One Penstock Gate.

The fact of being able to contract for all the machinery in the plant with one contractor is of advantage to the customer from more points of view than one.

The generators are 500 kw, three-phase, 60-cycle, 2,000-volt, 100 r.p.m. machines of the revolving field type. The armature or stator rests on the cast iron supporting ring mentioned in the description of the building. Above the rotor is a guide bearing supported by a heavy housing which is bolted to the stator frame. The rotor itself is mounted on a short length of shaft the lower end of which, below the collector rings, has a forged flange for connection to the half coupling mounted on the upper end of the wheel shaft. The stator sets slightly above the operating floor level.

For excitation, a motor-driven exciter is provided, the motor being of the induction type of 75 h.-p. It is a three-phase, 2,600-volt, 680-r.p.m. machine with independent starter, and is direct connected to a 45-kw., 125-volt compound-wound generator, both machines being mounted on a common bed plate. This unit has ample capacity for two generators with their heavy overloads and 75 per cent. power factor. The present plant has spare exciters of its own and it is planned to use them in case of a breakdown in the new unit.

The guarantees on the electrical apparatus are as follows:

Heating: 500 kw., 100 per cent. power factor; for 24-hour run a rise in temperature of not over 40° C. above surrounding air; 25 per cent. overload, 100 per cent. power factor, for a 3-hour run following above, a rise in temperature of not over 50° C. above surrounding air; capable of standing 100 per cent. overload momentarily; similar guarantees for auxiliaries.

Commercial efficiencies: At 100 r.p.m., with 100 per cent. power factor; full load, 94 per cent.; ¾ load, 93 per cent.; ½ load, 91 per cent. Inherent regulation of 8 per cent. or less from no load to full non-inductive load; full load current, 111 amp. at 2,600 volts; full load excitation, 120 amp. at 120 volts, 100 per cent. power factor; full load, excitation, 145 amp. at 120 volts, 100 per cent. power factor.

The Switchboard.—The switchboard furnished by the General Electric Co. is of 2-in. blue Vermont marble 21 ft. 4 in. long and is divided into eleven panels. Each generator has its own panel as has each feeder, a blank panel being provided for a future line. At the end of the board near the present station is a panel for cross connection between the two stations. The panels are placed in the following order beginning at the left hand when facing the board: exciter, exciter motor, regulator and auxiliary circuits, auxiliaries and station wattmeter, generators 1 and 2, feeders 1, 2, 3, and blank and the cross connecting panel.

For all 2,600-volt connections type K3 oil switches are used. They are mounted on a pipe framework behind the marble panels, the operating connections being made by bell cranks and rods, the latter across the intervening space below the floor. The two sets of bus-bars are overhead supported on insulators so that there are no high-voltage circuits on the front board. From the switches the generator leads pass up and across the space between the supporting frame and the wall, down this wall on insulators and to the machines on the ceiling below. All but one set of feeders (this one passing through the wall directly behind the switchboard) follow the same course, but are carried under the lower floor and across to the air ducts below the step-up transformers. The proper wires will pass up through sealed insulators each pair under its own transformer, where connections will be made.

The transformers to be used and also the blowers are at present in use by the company. From the top of the transformers the 10,000-volt connections are to be made through K4 oil switches and lightning arresters mounted on the end wall of the building. There are disconnecting switches in the ground wire as well as in the line wires. Overload relays are provided in all circuits except in the generators. On one feeder two banks of transformers will be used. To take advantage of the increase in efficiency at full load, the primaries and secondaries of these banks are controlled separately at the board as well as on the high voltage side, differential relays being provided as a safeguard to prevent the feeding back of current into either bank of transformers should a ground occur in the circuits between the switches, and also to avoid core loss when the transformers are disconnected from the bus-bars.

Miscellaneous.—The Whiting crane is of 15 tons capacity, operated by hand. It has a Yale & Towne hoist attached to the trolley carriage.

The station lighting in general will be done by incandescent lamps grouped in clusters and located on the face of the pilasters. For the lower floor individual lights will be located on the ceiling to give general illumination and to provide outlets for extension cables to the penstocks and elsewhere as deemed advisable. The wiring will probably be done in conduit, run open. It is planned to control the various circuits from a switch panel located on the building wall near the exciter unit.

The following comparisons will be of interest:

Plant.	Sewall 1.	Garvin.	Sewall 2.
Head, ft.	16	26	16
Units, kw.	1,000	3,950	1,000
Units, type	Hor. belt	Hor., d.c.	Vert. d.c.
Sq. ft. bldg., per kw.	6.45	2.74	2.45

The development at Garvins Falls, as well as the changes and addition now being made to the Sewalls Falls plant, as above described, were planned and carried out under the direction of Messrs. Hollis French and Allen Hubbard, consulting engineers, of Boston. The writer had charge of the major part of the details of both plants in the above office and Mr. G. G. Shedd was the resident engineer at Garvins for the later development and now holds a similar position for the development above described for the same firm. Mr. J. W. Rollins, Jr., of the firm of Holbrook, Cabot & Rollins, Inc., of Boston, is doing all the construction, with the exception of the superstructure, which is contracted for by Maguire & Penniman, of Providence, R. I. The structural steel was furnished by the Providence Steel & Iron Co., of the above city, and the reinforcing steel by the Abershaw Construction Co., of Boston.

Government Contracts; Legal Pitfalls and How to Avoid Them.—IV.

By George A. King and William B. King, Members of the Bar of the Court of Claims.

Alterations and Extras.—One of the most frequent causes of difference between government contractors and government officers is found in questions relating to alterations or extras. Many such cases have come before the courts and the decisions in these have varied under different conditions. In this Chapter an effort will be made to show by examining the decided cases what rules have been established by the courts in relation to this subject and what points still remain in doubt. Unfortunately there is still a considerable field of unsettled problems. Practical rules in relation to all such matters will then be submitted with the idea of helping contractors to avoid controversy in carrying out their contracts.

Authority of Officer to Order Extras.—Almost all questions arising on this fertile subject of controversy are ultimately settled by the doctrines of the law relating to the powers of agents of the government. Difficulties in which contractors find themselves in regard to alterations and extras are largely caused by their overlooking the difference between the law of agency as applied to private individuals and as applied to government officers. This was stated many years ago by the Supreme Court substantially in the following language: "Individuals as well as courts must take notice of the extent of authority conferred by law upon a person acting in an official capacity. Different rules prevail in respect to the acts and declarations of public agents from those which ordinarily govern in the cases of mere private agents. The government is not bound by the acts and declarations of its agents unless it manifestly appears that the agent was acting within the scope of his authority or that he had been held out as having authority, or was employed in his capacity as a public agent to do the act or make the declaration for the government."

The Court of Claims in another recent case has stated practically the same thing: "Officers of the United States in their official capacity are special agents acting within legally prescribed limitations; beyond those limitations no responsibility attaches to their acts as against the government; and where an officer acts in subordination to the authority of a superior officer he has no discretion to bind the United States beyond the limits of his delegated powers."

The question which must always be asked by a contractor when any order is given for extras or alterations is whether the particular officer giving the order has the authority to bind the government as to that particular thing. If he has such authority, then the responsibility is upon the government to pay for what he orders. If his power to bind the government in this particular matter is limited by any provision in any Act of Congress, or Departmental regulation, or in any portion of the contract, or if his authority is not expressed in the contract or directly inferable either from the contract or from some statute, his act in ordering such extra work or alteration is not the act of the United States and does not bind the government to any responsibility. The distinction is not always easy to make, but some cases where the question of responsibility has been decided will show how this principle has been applied.

Authority Recognized.—A contract made during the Civil War for the gunboat Ozark required "the vessel to be completed in every respect" and that the contractor should supply any omission "and for which there are to be no extra bills presented." Alterations were made by written order of the Secretary of the Navy and the government was held bound for these, on the ground that they were additions by proper authority not contemplated in the original contract. There was no provision in this contract providing any particular mode of ordering extra work.

The contract for the Puget Sound Dry Dock contained the usual provision requiring all orders for extra work to be in writing and approved by the chief of a naval bureau. The Secretary of the Navy visited the work and personally ordered some additional and unnecessary expense. The Supreme Court disregarded the provision of the contract fixing the mode of ordering extra work and said that the Secretary of the Navy himself had the power to over-ride the provisions of a contract made by a subordinate under his direction and could personally direct extra work to be done and bind the United States to pay for it.

In both of these cases it is to be observed that the orders for extra work came from the head of the department and that whether written or verbal his orders were authoritative. These decisions rest upon the theory that the head of the department is the authorized agent of the government, in all matters relating to his department.

In other cases the powers of subordinate officers to order extras or alterations have been recognized. A contract was made in 1876 by a series of letters with the Navy Department for completing the restoration of the frigate Constitution. The specifications contained no special provisions in regard to extras. The work was done under the superintendence of a naval constructor as a representative of the Navy Department. He gave many orders for extra work. Payment was refused by the department, but the items of extra work so ordered was allowed by the Court of Claims. The court said that the constructor was "the responsible and authoritative agent of the United States, and as such ordered and directed the claimant not only in the performance of the agreement as to the work specially provided by the contract, but also in the addition of such extra work as they might agree from time to time to attach to the original undertaking."

This case seems to establish the principle that in the absence of any special provisions as to extras the local officer is the agent of the United States to order them.

A contract was made for reconstructing a building at the Norfolk Navy Yard, which had been destroyed by fire. The walls were left partly standing. Before the contract was made portions of the walls were torn down and the contractor bid to add his work to the walls still standing and thus complete the entire building. His contract was made with the Navy Department acting through a bureau chief. It said that no extra charge for modifications would be allowed unless agreed upon by the parties. As the work progressed the local naval authorities decided that a portion of the walls remaining was unsafe and the contractor was obliged to tear these down and substitute new walls. No special agreement for an extra charge was made. He claimed the value of the new wall substituted for the old standing wall and the Supreme Court allowed it to him as extra work, not contemplated by the original contract.

This was apparently treated as an order by competent authority, although not the authority making the contract.

A contract was made just after the Civil War for building a fire-proof storehouse for the Quartermaster's Department, at the Schuylkill Arsenal. Orders were given by the officers in charge of the construction to do extra work not contemplated by the original contract. The contract contained a provision requiring modifications to be agreed upon in writing, but these were not required to have the assent of any superior officer. It was held that the verbal orders of the officers in charge of the construction were a due modification of the contract and waived the requirement of writing. Accordingly the contractors were allowed to recover for their extra work. It must be remembered that in this as well as in some of the other cases cited the verbal orders were held valid only because the contract had been executed by doing the work. They would not have formed a basis for a suit for loss of profits, had they been revoked before the work was done.

A contract for reconstructing the Mussel Shoals canal, in Tennessee, was made by the officer of the Engineer Corps in charge of the work, the approval of the Chief of Engineers not being required. This provided that no extra work should be paid for unless, in advance of the work, the prices and quantities had been "agreed upon by the contracting parties and approved by the Chief of Engineers." The officer in charge, who had made the contract, ordered a large quantity of additional embankment. The court said that this officer had the same authority to order the extra work that he had to make the original contract and consequently could set aside the express provision of the contract which he himself had made. The court in this case found that the performance of the extra work was known to the Chief of Engineers and inferred in that way an acquiescence and a ratification but conceded that, even without this, the officer who had made the contract was the authorized agent of the United States to order extra work to be done under it.

It is not easy to deduce from these cases any rules of general application without danger of running counter to decisions adverse to the powers of local agents and engineers which will be cited hereafter, still the following may apparently be justified by these cases.

1. The head of a department may bind the United States by any order for alterations or extras, whatever may be the provisions of the contract.

2. The officer in charge of the work, if the contract contains no special provisions fixing the mode of ordering extras has authority to do so.

3. If the contract contains special provisions fixing the mode of ordering alterations or extras the United States will be bound if they are ordered in some other manner, by or with the approval of the highest officer whose approval was necessary to the validity of the original contract.

4. If the approval in writing of any particular officer is required by the contract, such officer can waive the writing and bind the United States by a verbal order.

Authority Not Recognized.—Cases like any of these are now exceptional. At the present time most government contracts are signed by one officer and approved by a superior and the mode of ordering extras is strictly limited, nearly always requiring the approval of the superior who approved the original contract. In very few cases does the head of a department issue personal orders in derogation of the contract provisions.

The common provision in the engineering contracts of the War Department is substantially as follows:

"No claim whatever shall at any time be made on account of any extra work or material performed or furnished by virtue of this contract, and not expressly bargained for and specifically included therein, unless expressly required in writing by the party of the first part or his successor, the prices and quantities thereof having been first agreed upon by the contracting parties and approved by the Chief of Engineers."

Another form used in the Navy Department is as follows:

"If at any time it shall be found advantageous or necessary to make any change, alteration or modification in the aforesaid plans and specifications, such change, alteration, or modification must be agreed upon in writing by the parties to the contract, the agreement to set forth fully the reasons for such change, and the nature thereof, and the increased or diminished compensation, based upon the estimated actual cost thereof, which the contractors shall receive, if any."

Other similar forms are in use in other departments.

A great many cases have come before the courts under these provisions where the contractors have done extra work, beyond that contracted for, upon orders not strictly complying with the terms of the contract and have claimed extra compensation. They have been decided upon the principle which has already been stated—the determination of the authority of the officer ordering the extra work to bind the United States. The cases already cited have shown when the authority of such an officer has been recognized. It is now necessary to review the cases where this power has been denied. In general, these cases have arisen under provisions like those just above quoted.

The leading case in regard to such contract provisions was decided by the Supreme Court in 1877. It arose in connection with the erection of the United States court house at Raleigh, N. C. This contract provided that there should be no departure from its conditions without the written consent of the Secretary of the Treasury. Rubble stone was required by the contract and this the contractor furnished, claiming that it fulfilled the contract requirements. The superintendent in charge refused to receive it and told the contractor that he must furnish range-rubble or broken ashlar, more expensive than rubble. The contractor complied with this requirement and furnished the superior stone, telling the superintendent that he should expect higher pay for it. He did not inform the Secretary of the Treasury that he claimed to be furnishing better stone than required or that he should ask higher pay for it. The Supreme Court said that the claimant might have declined entirely to furnish the superior stone required by the superintendent and thrown up the contract on the superintendent's insisting upon a course probably involving him in serious loss, or he could have given notice to the Secretary of the Treasury that he was required to do work in excess of the contract provisions and left it to him to decide whether these requirements should be insisted upon. "If he had done so," the Supreme Court said, "the proper authority would have had an opportunity to detemine whether the directions given should be over-ruled, or whether the wall should be constructed as proposed by the assistant superintendent. Nothing of the kind was done, and the opportunity was lost to the United States to exercise any option in the matter."

This reasoning is based upon the idea that the claimant's objection and notice was to an officer totally unauthorized to modify the contract or to represent the United States in relation to it. Had he notified the Secretary and then been required by him to furnish stone better than that contemplated by the contract, the inference is plain that the Supreme Court would have recognized his right to recover the difference in value between what the contract required and what he furnished.

This ruling is an extreme application of the principle of the limited agency of government officers, but it has been cited and followed in many later cases, as a correct rule of strict law. That it worked an injustice to the contractor was subsequently admitted by Congress. An act was passed a few years later paying the contractor the excess in value of the better materials furnished by him over the contract price. The very fact that Congress so recognized the severity and injustice of the rule laid down in this case may well make some question as to whether it is sound as a rule of strict law. The contractor obeyed an order issued to him by the officer set in immediate authority over him, supposing him to be acting in accordance with the wishes of his superior; the government got the benefit of his increased expense in the form of a better building and Congress evidently thought that fair dealing required the government to pay for what it required under such conditions. However harsh its effect, it is now settled as a rule of law and nothing more can be expected than that the courts will limit its application to those cases which necessarily fall directly within it. Fortunately for contractors there are some signs of such a judicial tendency.

Very shortly after the decision of this case a claim was brought before the Court of Claims under a contract for building a breakwater on Lake Michigan, for extra work required by the local officer in charge. The court followed the former case exactly and held that it was the contractor's duty before doing this work to see that the agent who ordered the change had authority from Washington to do so.

In a later claim arising out of the construction of levees in Louisiana, the Court of Claims refused payment for extra work done under orders of the local officer, but not approved by the Chief of Engineers, and said that such a decision was necessary in order to protect the rights of that officer, by whose approval the contract was made.

In another contract for dredging in the Delaware River, the same rule was again applied and the court declared that the officer in charge who ordered the extra work represented the government only to the extent of superintending the performance of the work, and had no power or discretion beyond that. They said that the right and power of the Secretary of War and Chief of Engineers could not be superceded by the action of any local officer immediately in charge.

When the custom house at New Haven was built, the contract contained a similar provision requiring the approval of all orders for extras by the Supervising Architect of the Treasury. The Court of Claims said that he was the authorized agent of the United States, and that the local superintendent in charge of the work could not bind the United States to pay for extras. The contractors argued that the United States had received the benefit of this extra work in the building and was bound to pay for it. This was answered by saying that the building had to be accepted as an entirety and the United States had no opportunity to refuse the extra work. The claim for extra pay was dismissed. It was admitted that the decision would have been different in a case involving the delivery of supplies or material, where the government could have refused the extra quantity.

In constructing the Naval Observatory at Washington, extras were furnished by order of the architect in charge of the work. The fact that these orders were in writing did not change the general rule. The Court of Claims denied the claim for extras because the approval of the Secretary of the Navy had not been obtained.

The most extreme application of this doctrine occurred in a recent case arising out of the erection of the post-office building at Chicago. This contract was made by the Supervising Architect of the Treasury with the approval of the Secretary of the Treasury. It provided that no extras should be allowed unless "authorized in writing by the Supervising Architect under the approval of the Secretary of the Treasury." A number of expensive changes were ordered by the Supervising Architect on the recommendation of the local superintendent, but without the express approval of the Secretary. The Court of Claims decided that the contractor could not be paid since the Supervising Architect himeslf, although in Washington, acting directly under the eye of the Secretary of the Treasury, could not order these changes and that the approval of the Secretary of the Treasury would not be implied from the action of his subordinate. The authority of this decision has been questioned in a pending motion for a new trial, suggesting that the Supervising Architect should be presumed to act with the approval of the Secretary of the Treasury unless the contrary is shown.

The last important decision on this subject is a further illustration of the same rule of the limited powers of subordinate officers as agents of the government. A contract for the mail messenger service in the city of Boston, was made by the Postmaster-General. The contractor was ordered by the postmaster of Boston to carry the mails from the Back Bay station in that city to Brookline, an independent post-office. The contractor protested, but the order was enforced. After submitting for a considerable period the contractor carried his protest to the Postmaster-General, who sustained it and relieved him of the extra service. The contractor sued for the value of this service as rendered during the period between the postmaster requiring it and the Postmaster-General relieving him. The Supreme Court said that he could not recover for this, because the postmaster had no right to bind the United States to pay for such extra service.

All these cases illustrate very clearly the rule of law stated in the beginning of this discussion—that officers of the United States are limited in their authority as agents and that this authority cannot be extended by presumption beyond its express limits or those necessarily implied.

The responsible and authoritative agent of the United States in making a contract is the highest officer whose approval is necessary to make it valid. If the contract requires his authority for making changes, the subordinate officer in charge is not the agent of the government to authorize alterations or extras or to waive the provisions of the contract requiring such approval.

Ratification of Authority.—A vessel was purchased for the transport service in the Spanish War, but certain changes were necessary, and the contract for the purchase of the vessel, made by the Quartermaster-General, included the alterations. As the work progressed the local quartermaster discovered much more work to be necessary. In this the military officer commanding the department concurred. The contractors did this work upon the order of this quartermaster. The bills for the extra work were submitted by him to the Quartermaster-General and approved by him. The Treasury Department refused to pay for the extra work on the ground that it was done without proper advance authority from the Quartermaster-General. The Court of Claims held that his subsequent approval was sufficient authority and awarded compensation for the extra work. This decision applied to government contracts the old rule of private business that subsequent ratification is equivalent to prior authority. It is readily seen that this is no exception to the general rule limiting the powers of inferior authority, but is rather an application of that rule to different conditions.

Work Not Conceded to be Extra.—These provisions for written orders for extra work are clearly applicable to work which both parties regard as extra. But a large proportion of the claims for extra work which have come before the Court of Claims are of controversies between the contractor and the government officer in charge over the extent and effect of the contract requirements. The government agent, engineer or inspector says that certain work is required by the contract; the contractor denies it. Clearly there can be no signed agreement for extra pay in such cases because the government denies that there is extra work.

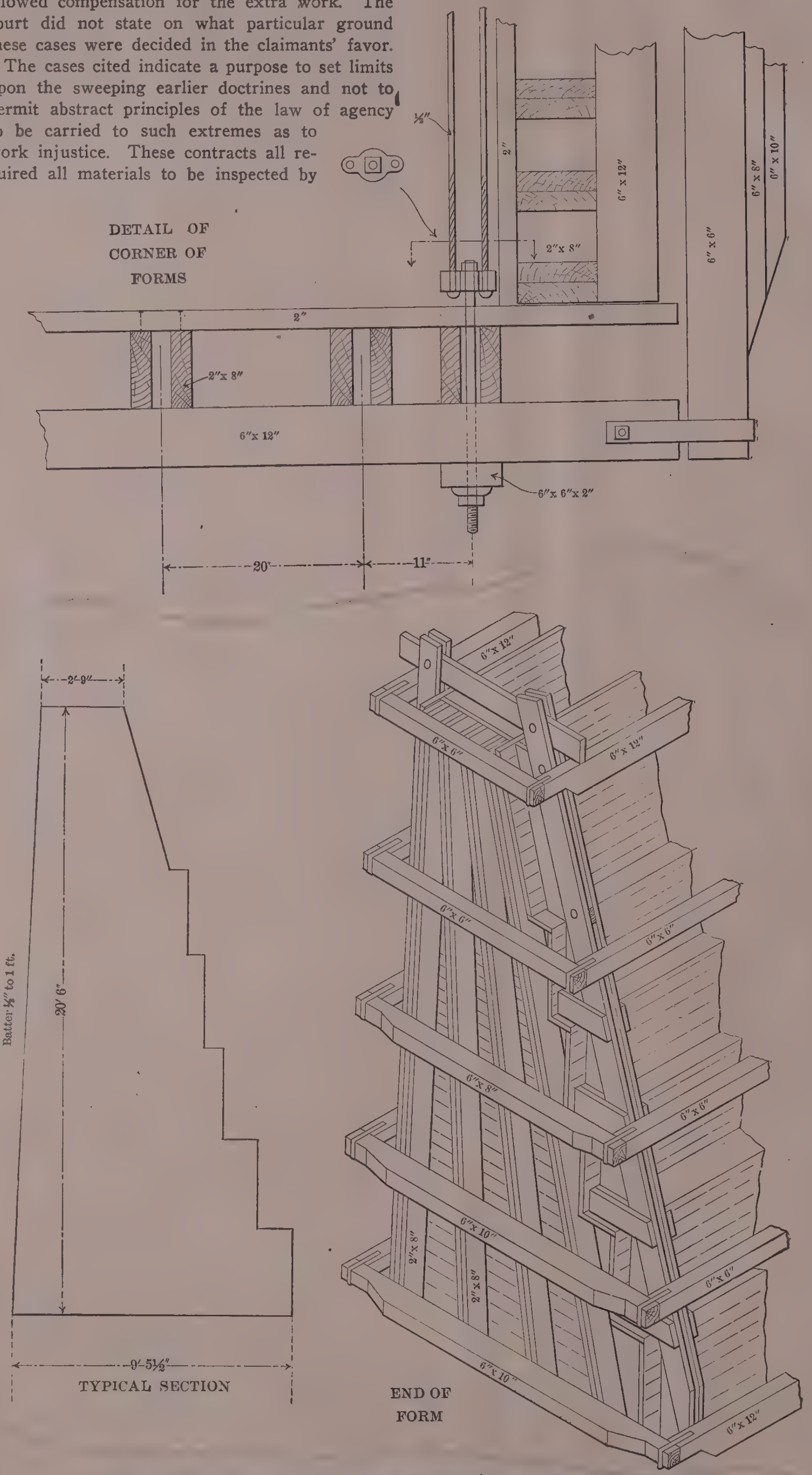
The proper course, if the contractor desires to protect his rights absolutely, is very clear. He should notify the officer in charge in writing that he considers the work required of him to be outside of his contract and that he will expect extra pay for it. He should send a similar notice to the highest officer who approved his contract or whose authority is necessary to a valid modification of it under its terms. In this way only can he be sure that his right to additional compensation will be sustained. If he fails to give such notice to the superior officer, can his claim for extra pay be allowed? There are several decisions of the Court of Claims which sustain the distinction that if the work is ordered avowedly as extra work, the contract provisions requiring approval by a superior must prevail; but if the work is asserted by the local government officer to be within the contract and this is denied by the contractor, the order of the local representative may be sufficient authority for extra pay. This is illustrated by several cases in which extra compensation was allowed, although the superior officer was not consulted or informed.

The contract for rebuilding the government building at Savannah contained the usual provision that no additional compensation would be allowed unless the price was first fixed and the work authorized by the Supervising Architect. The contract provided for an elevator of a given design, but of no particular make. The local superintendent asserted that the elevator of one manufacture only could be used under the contract. The contractor claimed the right to put in a less expensive elevator, but, without order or knowledge of the Supervising Architect, yielded and put in the more costly elevator. The Court of Claims allowed him the difference in the cost.

A decision similar to this was made by the United States Circuit Court in Georgia, in a suit growing out of a contract for building fortifications near Savannah. This contract contained the usual provision forbidding any payment for extra work or material without the approval of the chief of engineers. One paragraph required sand to be mixed partly of river sand and partly of beach sand. The officer in charge required the contractor to furnish all river sand, at a greatly increased expense. The engineer also required a large quantity of pipe to be furnished, although none was specified in the contract. The court held that there was an implied contract by the government to pay for the extra cost of the sand and for the pipe. His control over the work as engineer in charge was such as to make his action binding on the government even in the face of the specific provision of the contract.

The same rule was followed in the Court of Claims, in claims for extra work under the Quartermaster's Department of the Army at Fort Myer and at Fort Ethan Allen. Both of these contracts were approved by the Quartermaster-General before being effective; in neither case was his approval secured to the extra requirements; in both cases the officer in charge declared, and the contractor denied, that the work was within the contract; in both cases the court allowed compensation for the extra work. The court did not state on what particular ground these cases were decided in the claimants' favor.

The cases cited indicate a purpose to set limits upon the sweeping earlier doctrines and not to permit abstract principles of the law of agency to be carried to such extremes as to work injustice. These contracts all required all materials to be inspected by the officer in charge and all work to be done under his direction and to his satisfaction. It may be said that this made the officer in charge the agent of the government to construe and enforce the contract and that his act was the act of his superior unless disapproved.



DETAIL OF CORNER OF FORMS

TYPICAL SECTION

END OF FORM

Retaining Wall Construction, New York Central Terminal, New York.

Practical Rules.—It is not possible to speak with entire certainty as to some of the rules of law on the subject of extra work, but the following may be submitted as safe working rules for the guidance of contractors:

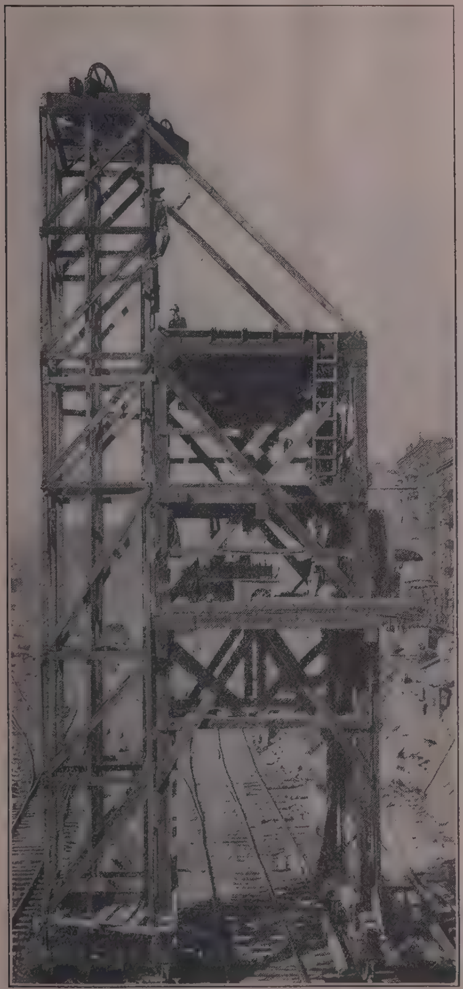
1. All orders for what the contractor believes to be alterations, changes, extra work, or any sort of departure from the terms of the contract should be obtained in writing. If the officer giving the order will not put it in writing, the contractor should do so by written acknowledgment, quoting the order in writing.

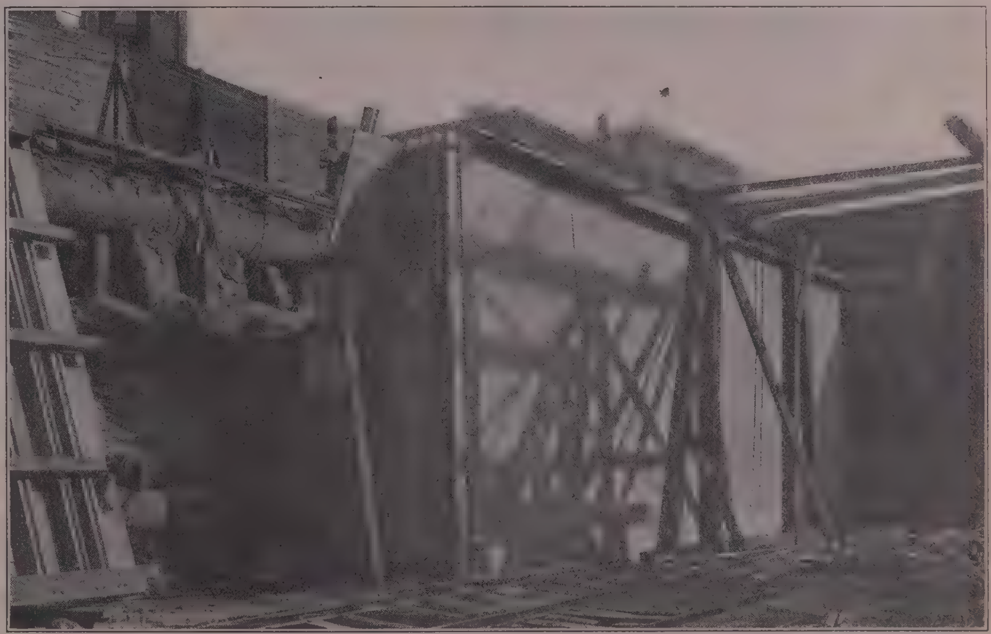
2. The contractor may with safety obey the written order of the highest officer who signed or approved the contract for any alterations or extra work within the general subject matter of the contract, taking care to let it be known to such officer that he regards it as extra.

3. The contractor cannot with assurance of safety obey an order of the engineer or officer in charge for any alterations or extra work, unless the contract was made by such officer without the approval of a superior officer.

4. On receipt of any order for what the contractor considers alterations or extra work, not required by the contract, involving extra expense, the contractor should at once notify the officer issuing the order that he considers it extra work and will expect extra pay therefor.

5. If such order comes from any officer lower than the highest officer approving the original contract, the contractor is responsible for seeing that such highest officer knows of the order and of the contractor's position in regard to it. He should notify such officer himself unless he has positive knowledge that such notice has been sent by the officer in charge.





Traveling Concrete Mixer and View of Retaining Wall, New York Central Terminal, New York.

6. Following these rules will save the contractor's rights to extra compensation either before the departments or the courts.

7. If such detailed precautions are not always taken, it by no means follows that redress cannot be obtained in the Court of Claims for oppressive exactions. The variety of possible conditions of fact makes it impossible to state, further than in the general manner already outlined, the exact cases where relief will be granted.

The Court of Claims always endeavors to do justice to contractors who have been obliged to exceed the obligations of their contracts, although sometimes unable to do so by reason of rigid rules of statute or fixed general principles of positive law.

Rigid adherence, in the protection of the contractor's rights, to the course outlined above may sometimes be thought impossible by reason of the too sensitive disposition of a government superintendent or engineer. The contractor's exact course of action may be tempered by a recognition of this fact, but with care and tact, the essential steps above outlined can usually be followed in substance without giving serious offense.

(To be Continued.)

Tests of Large Shaft Bearings.

Tests of large shaft bearings were referred to by Mr. Albert Kingsbury in a topical discussion at the recent meeting of the American Society of Mechanical Engineers. The apparatus tested was a large horizontal shaft rigidly supported in two bearings, each 9 in. diameter and 30 in. long, with a third bearing 40 in. long, on an enlarged section at the middle, 15 in. in diameter, which was subjected to upward pressures of 25 to 50 tons. The shaft was driven by a Westinghouse 150-h.-p. railway motor, the electrical drive providing a means for estimating the friction of bearings. The shaft journals and babbitted bearings were very carefully trued, the clearance over the top and sides being 0.03 in. in the larger bearing and 0.008 in the smaller ones. The larger bearing could be water-cooled and all bearings were flooded with oil. The thickness of the oil film was found to increase under these conditions with the speed, varying from practically nothing at 300 r.p.m. to over 0.003 in. at 1,200 r.p.m. It was found possible to run the bearings with loads and speeds greatly exceeding the ordinary values in practice even without water-cooling the bearing sleeve. Perhaps the most interesting determination was that the power required to drive the shaft was very nearly proportional to the speed of rotation, independently of all other conditions, such as load, final temperature attained and lubricant used; this was not taken as a general law but was referred to as noteworthy even as an accidental relation. With a constant loading of 25 tons, the power required to drive varied from 5⅛ to over 21½ h.-p. as the speed of the shaft increased from 179 to 506 r.p.m. but with constant speeds and variable loads the results show no variations of power required.

Concrete Retaining Walls at the New York Central Terminal, New York.

At the Grand Central Station of the New York Central R. R., the yards have been extended to a total area of about 43 acres and are depressed to an average distance of about 20 ft. below the adjacent streets, being enclosed by massive concrete retaining walls. The wall varies from about 11 to 21 ft. in height and has a batter face with rear offsets 3 ft. high, as shown in the cross-section. It is made in full-height sections about 52 ft. long, with open vertical transverse expansion joints ⅛ in. thick between them. The moulds are built with horizontal 2-in. Virginia pine planks, ship-lapped ½ in. and laid ⅛ in. apart to allow for swelling. They are lined on the face with thin steel plates, and are secured by vertical spruce joists and removable horizontal yellow pine waling pieces, bolted on as indicated in the illustrations. The front and end sheeting is made in single large surfaces, but the rear sheeting is made in steps to correspond with the offsets, each one having a vertical and a horizontal part fitted to the framework like the tread and riser of a stair .

The waling pieces are fastened at the corners of the moulds by U-straps of 2x½-in. iron bolted to the longitudinal pieces and projecting beyond their ends to engage the chamfered ends of the transverse strips. Intermediately the longitudinal waling pices are tied together through the mould by pairs of horizontal ½-in. rods 2 3/16 in. apart, with hemispherical upset heads at each end, engaging cast-iron sockets shown in the detail, which are placed just inside the sheeting and are secured by short bolts with nuts engaging the castings. The opposite ends of the bolts have nuts taking bearing on the waling pieces. After the concrete has set both nuts are unscrewed and the bolts removed, leaving the castings and the ½-in. rods permanently embedded in the concrete. The mould panels weigh from 2 to 3 tons each and are handled by the 45-ft. boom of a locomotive crane built by the Browning Engineering Co.

The first mould was assembled with both ends closed by sheeting and after it was stripped from the concrete two moulds were used and sections were built on both ends alternately allowing one section to set while another was being built. These successive sections are made with moulds having front and rear sheeting and sheeting at the outer end only, the previously finished concrete closing the rear end of the mould where the front and side panels of sheeting overlap the faces of the concrete and are tightly clamped to it by the horizontal transverse rods. It takes a force of 20 men about 3 hours to strip a mould and it takes 20 men about 7 hours to reassemble it and oil the inside ready to receive the next section of concrete. As the work progresses it is intended to have 3 sets of moulds and prosecute the wall building simultaneously at as many points.

Concrete is mixed and delivered to the moulds without hand work by a movable plant which is operated entirely by electricity and is installed in a 13x16-ft. wooden tower 40 ft. high, which has eight double-flange wheels traveling on a track of 13 ft. 2 in. gauge about 5 ft. clear of the face of the wall. A standard-gauge track on the center line of the tower track receives material cars which run through the tower with a clearance of about 12 ft. horizontal and 14 ft. vertical and are unloaded by hand on a platform parallel to the track where they are wheeled to a pair of Ransome 1-yd. steel automatic tilting buckets operated by a Lidgerwood hoisting engine in the tower. The buckets run in vertical guides extending 16 ft. above the top of the tower and deliver to two 10-yd. hopper-bottom storage bins about 7 ft. above the mixer floor where 400 bags of cement are stored which are hoisted by whip lines operated by the capstan head of the hoisting engine.

The storage bin chutes are fitted at the bottom with horizontally pivoted troughs which close them when raised and when lowered allow the sand and stone to be discharged to the measuring hopper where the cement is emptied and all is delivered to the mixing machine while the revolution of the latter is uninterrupted. The mixer and hoisting engine are operated by independent General Electric motors and the mixer delivers through an inclined chute to an end-dump tilting 1-yd. steel car which runs across the top of the mould on a 24-in. longitudinal track and distributes the 1 :3 :6 Atlas Portland cement concrete as required for the laborers who place in it one-man stones and carefully spade the mortar around the sides of the mould. The concrete is mixed wet and requires no ramming. Each mould holds about 250 cu. yd. and the best record of filling it is 6¾ hours for 60 men including those in the tower. The moulds are stripped the next morning after being filled, and concreting for each mould is continuous until it is completed. The total number of men employed on the concreting and handling the moulds is about 75 and the largest record is 2,700 yd. of concrete in one month. The concrete work is being done under the direction of Mr. W. J. Wilgus, vice-president, and Mr. A. B. Corthell, terminal engineer, and is being executed by the O'Rourke Engineering Construction Co.

Shaft Bearing Practice is tending toward higher temperatures, according to Mr. A. M. Mattice, who stated in the topical discussion on bearings at the recent meeting of the American Society of Mechanical Engineers, that in his examinations of large numbers of engines in service, he has found more bearings hotter than 135° F. than cooler; in many cases, temperatures as high as 150° F. are maintained constantly without trouble, while one instance of an operating temperature of 180° F. was cited. Where engines are direct-connected to generators, the bearings are subject to much greater rises of temperature than in other classes of machinery, as the proximity of the heated generator and other parts prevents the ventilation which is necessary for proper cooling.

The North Mountain Power Co.'s Plant near Junction City, Cal.

Among the power-transmission systems of the Pacific Coast, that have been constructed with an eye to the future, rather than the present needs of the communities which they serve, one of the most interesting is that of the North Mountain Power Co. This is located in the central part of Trinity County, Cal., 2 miles below the town of Junction City, where Canyon Creek, from which the water used for power is obtained, flows into the Trinity River. Weaverville, the county seat, is 12 miles distant by road. The nearest railroad point is Redding on the Shasta Route, of the Southern Pacific R. R., Humboldt Bay, on the Pacific Ocean, with Eureka, the chief coast city of northern California, lies almost due west, 59 miles in a straight line.

The altitude of the plant is about 1,480 ft. All material, cement and machinery were hauled over 60 miles of the severest mountain roads, across three distinct divides or summits, viz.: Trinity Mt., Brown's Mt., and Oregon Mt. It required eighteen to twenty animals to pull each of the larger pieces weighing 18,000 lb. up the grades, and when mud was encountered it was necessary to hitch eighteen animals to the fall of a block and tackle fitted with steel cables. Despite these difficulties, however, no mishap occurred to any of the machinery.

General View of Trinity River Power Station

Watershed.—The water used at the plant is diverted from Canyon Creek, which has a drainage area of 52 square miles above the diverting dam. The upper part of the basin is a rugged, glaciated granite country, extending up to an altitude of from 9,000 to 10,000 ft. above sea level, where some snow remains throughout the year. The higher parts of this basin are in the nature of an immense amphitheater, lying on a flank of Thompson Peak, which is a characteristic feature of all elevated glaciated topography. And, as is so often the case, the converging and descending glaciers have scooped out immense holes with almost perpendicular sides, which now form the beds of two lakes. These have been utilized as storage reservoirs. Part of the watershed is heavily timbered, and lies within the boundaries of a government forest reserve. This will insure the preservation of the forests, which are so effective in steadying the run-off.

The average annual rainfall for the last 33 years at Weaverville has been 42.50 in. At the higher levels of the watershed the precipitation is much greater, but no records are available for that region because the country is absolutely uninhabited, and without even trails, except for the one to the above mentioned lakes.

Canal System.—The dam is small, and serves merely for diverting the water. It is of the usual rock-filled crib type used for many years in mining operations on the Pacific Coast.

The canal system consists of alternating sections of ditch, flumes, and one tunnel. Part of the ditch is cut in solid rock, but the most of it is dug in the sidehill soil which stands well and puddles well.

The flumes are nineteen in number and vary in length from 30 to 1,200 ft. Those immediately below the dam are laid upon a solid bedrock bench, and equipped with adequate spillways, wastegates and sandboxes. The total length of the flumes is 5,250 ft.

A tunnel 1,521 ft. long has been driven to replace a temporary flume which was unavoidably built upon treacherous sliding ground. This tunnel is heavily timbered throughout its entire length, and tightly lagged except where the rock is unusually hard. The dimensions of the main tunnel are 4 ft. 9 in. by 5 ft. 10 in. in the clear.

The total length of the canal, flumes and tunnel is 7¼ miles. The average grade of all is 0.00184 or 9.73 ft. per mile. The canal is provided with waste gates and sand boxes at suitable locations. The capacity of the canal is 80 cu. ft. per second, which is sufficient to operate at full load three units like the two which are now installed.

Near its lower end the canal passes through a gap in the narrow ridge separating Canyon Creek from Trinity River and terminates in a forebay on the river side of the divide. Thus a head is secured due not only to the fall in Canyon Creek in the seven miles through which the creek and canal parallel each other, but also to the additional fall in a further course of 2 miles to the creek's junction with the Trinity River, and to the added fall in 2 miles of the river's course between the junction and the plant.

A telephone line extends from the power house along the entire course of the canal to the head dam. Instruments are placed in the station, the forebay tender's cabin, the head gate-tender's house, and at several other points along the line. Portable telephones can be readily connected at any point, and, as a result, any place along the canal can have prompt communication with the power house.

The forebay is excavated out of the solid rock of the hillside, 10 ft. deep, 14 ft. wide and 60 ft. long. The ditch is provided with a gate at its entrance to the forebay, and the latter contains a gate and grizzley at the intake of each of the two penstocks. Provision has been made for a third penstock when a third unit shall become necessary in the plant. Suitable trash-racks are provided just above the forebay.

The Penstocks.—The penstocks, two in number, are each 1,165 ft. long. Under a total head of 604 ft. there is an effective head of 600 ft., or working pressure of 260 lb. per square in.

There is one complete independent penstock for each of the two units. Each consists of a line of 36, 28 and, at the lower end, two lines of 18-in. riveted steel pipe of various gauges, according to its position in the line. At the Y's, or points where the single 28-in. pipe branches into two 18-in. lines, the penstocks are enclosed and anchored in a massive block of masonry laid up with imported Portland cement mortar. At their lower ends, just before entering the power house, they are secured by a similar form of construction, and at various points they are held by bands and anchor bolts leaded and sulphured into the bedrock. Throughout their entire length they are laid in trenches and covered by back-filling, except at their lower ends, where the profile of the hill is such that it was best to lay each in a separate tunnel. After completing and testing the penstocks, the tunnels were walled up and back-filled.

The penstocks are each provided with an 18-in. stand-pipe just outside the forebay walls to allow air to enter when the forebay gates are closed, and thus prevent collapse of the pipe. They are also provided with air-valves and manholes at suitable points.

The plant proper consists of (1) the power house, (2) the transformer house, and (3) the high tension switch house. In addition there are (4) the shop, (5) the operator's dwelling and (6) the stable. At the forebay is the forebay tender's cabin, and at the dam is a house for the tender of the head gates.

Power House.—Each of the two hydraulic units consists of a pair of 44-in. Pelton wheels under one sheet steel housing, provided with ring-oiling, self-aligning bearings, coupled to the generator through flexible leather link couplings. The nozzles are of the deflecting type. With the largest tips in service the wheels are capable of driving the generators at 25 per cent. overload.

The wheels are controlled by type F Lombard governors using oil. The pressure and vacuum are maintained by oil pumps belt-driven from the wheel shafts. The governors are not fitted with any form of switchboard speed control, but a single operator has no difficulty in synchronizing a generator under the load conditions which exist in the plant.

The tail race is 6½ ft. wide and excavated for 280 ft. through bed rock to the Trinity River.

The generators, two in number, are of the Bullock type, furnished by Allis-Chalmers Co., of Milwaukee, being three-phase, 750 kw, 500 r.p.m., 2,200 volts, 25 cycles, revolving field, 6-pole machines. Two Bullock exciters, 125 volts, 45 kw., 900 r.p.m., are driven by belts from the generators. The switchboards are of marble and have Wagner instruments.

The power house, 36x51 ft., is built of concrete made up with sand and gravel taken from the river bars a few rods from the site of the plant, and with imported Portland cement. A special bay or alcove has been provided to give ample space behind the switchboard. The roof is of corrugated iron supported on steel trusses. A Cyclops hand-operated crane spans the main part of the building and is fitted with a 20,000-lb. Triplex block. This easily handles the heaviest piece of machinery. The leads between the generators, exciters and switchboard are lead-covered cables laid in conduits within the concrete and cement floor.

Transformer House.—The transformer house is 13 ft. by 51 ft. 6 in., and also built of concrete. It is 50 ft. from the power house. It contains seven step-up transformers, viz.: Two banks of three each and one in reserve. They are of Bullock make, water-cooled, oil-insulated, 2,000/19,050 volts, 25-cycle. Each bank is located in a separate room, and the seventh or spare transformer is in a third room. They stand on rollers which in turn rest on tee rails set into concrete piers. The spaces between the piers are filled with gravel and provided with sub-drainage so as to allow any oil to escape rapidly in case of leakage or accident. The water piping is connected up with unions and so arranged that every transformer is interchangeable with every other one, as far as water and electric connections are concerned.

A track runs the entire length of the building and at such an elevation that the floor of a car is at the same height as the rails which are imbedded in the concrete piers. Thus any transformer can be quickly rolled out on the car, removed, and another reconnected in its place in case of accident.

The penstocks are each tapped in the power house, and after passing through shut-off and throttling valves under the control of the operator, water is delivered into a cylindrical steel tank, 36 in. in diameter and 24 ft. long. This storage tank is set on a little knoll about 20 ft. above the level of the transformers. From this tank the water circulates through the cooling coils of the transformers by gravity.

The transformers are connected in delta on the low-voltage side, and in Y on the high-voltage side, with ungrounded neutral.

High-Tension Switch House.—The high-tension switch house is 16x36 ft., a frame structure covered with corrugated iron, 20 ft. distant from the transformer house. In it are two banks of M-T single-throw air-brake switches, and General Electric alternating-current multiplex lightning arresters, connected up for the three-phase circuit.

Pole Line.—The pole line extends almost due west from the plant to the sub-station in Eureka. The length is 65 miles. Of this 55 miles are over a severely rugged mountainous country; the altitude of the plant is only 1,480 ft. and Eureka is at sea-level, but the line passes over several summits ranging from 4,500 to 5,500 ft. Fifty miles of its length lie in a heavily timbered country, requiring a tremendous amount of clearing, the trees ranging from 2 to 4 ft. in diameter. It was necessary to construct a trail nearly the entire length of the line. The route deviates from a straight line only slightly and only where the topography made it unavoidable. It is a "thorough" transmission, so to speak, there being no taps on the line anywhere between the plant and the sub-station at Eureka.

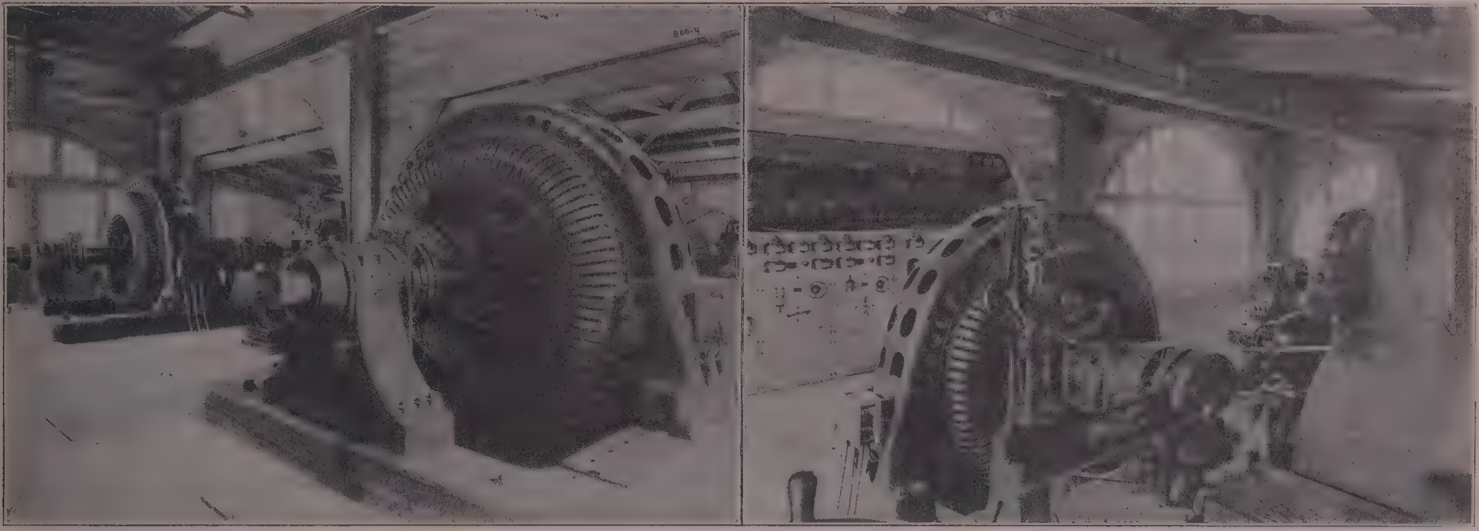
The line is a single-circuit, three-phase, averaging 35 poles to the mile. The poles are redwood at the western end; in the inaccessible stretches the native red fir was the only wood available. Insulators are Locke two-piece single petticoat porcelain, 8½ in. in diameter. In the fog belt a larger insulator of similar design is used. Pins are sun-dried eucalyptus, oiled, 1½ in.; wire is No. 4 copper, except on some long spans, where stranded cable is used. The length of spans varies from 50 to 1,400 ft., according to the conditions and topography of the country.

The telephone circuit is No. 10 B. B. galvanized wire, carried on glass insulators.

Stromberg-Carlson telephones are connected to the line at several of the cabins which have been built for the accommodation of the patrolmen, and at frequent intervals are pole-boxes, consisting of magneto-generator and batteries, into which the patrolmen plug their pocket sets and thus have long-distance loud-talking instruments.

The potential at present used on lines is 30,000 volts.

Sub-Station at Eureka.—The sub-station at Eureka includes an auxiliary steam plant as follows: Two Babcock & Wilcox water-tube boil-



Two Views in Trinity River Power Station of the North Mountain Power Company.

ers fitted with Peabody patent oil-burning furnaces, duplicate oil-pumping system; Goubert auxiliary feed-water heater; Wheeler "Admiralty" surface condenser with self-contained steam-driven air and circulating pumps, cooling water being taken from Humboldt Bay, and a McIntosh & Seymour tandem compound engine of nominal rating of 700 i.h.p. A jackshaft running at 500 r.p.m. is connected to the engine by a rope drive. A Bullock rotary converter, 500 kw., 500 r.p.m., 6-pole, 25-cycle, 550-volt, is arranged for direct connection to this jackshaft by a jaw clutch and so driven by the engine. This permits of carrying the load by steam when necessary to shut down the transmission line for repairs. The engine is fitted with a switchboard speed control device. The clutch has a synchronism indicator in the nature of a lamp, so that the engine may be connected to the rotary while it is running at full speed on the power transmitted from the Trinity River plant.

For the rotary converter there are three Bullock transformers, 190 kw., water-cooled, 25-cycle, 30,000/352 volts. For stepping down for the local distributing system are three General Electric transformers, 400 kw., water-cooled. For furnishing power to the 60-cycle incandescent and arc lighting circuits of the city of Eureka, a three-phase, 60-cycle generator is driven by the rotary acting as a synchronous motor.

A fuel oil tank 54 ft. in diameter by 25 ft. deep, holding 10,000 barrels, has been built near the sub-station, and is connected to a dock on Humboldt Bay by a pipe line.

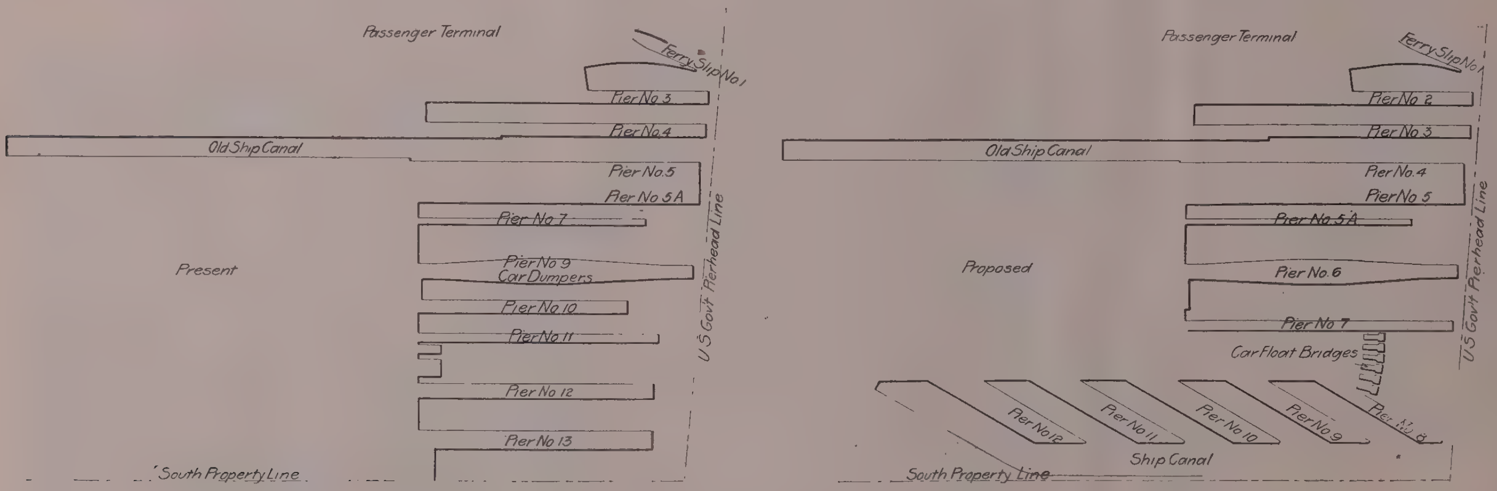
The sub-station is 31 ft. by 128 ft., built in the marsh on the water front of Eureka. Heavy concrete foundations rest on redwood piles cut off below low-tide level.

The load at present consists chiefly of lights in the city of Eureka. Some motors are already connected to the circuits, and the motor load is being rapidly developed. Local transmission lines are being constructed about the shores of Humboldt Bay and in a very short time the company will be supplying power to the local companies in Eureka's suburbs, not only for light but for motors in the various industries of that rapidly developing region.

Gas Engine Jacket Water is cooled at the gas engine electric lighting station of the Citizens' Gas & Electric Co. of Lorain, O., by discharging it into the water seals of adjacent gasometers. These furnish sufficient storage room to permit ample time for cooling. In winter there is an additional advantage that freezing of the gasometers is prevented, while in summer the large metal surfaces provide ample radiation capacity to keep the water cool.

The New Hoboken Freight Terminal of the Lackawanna R. R.

The Delaware, Lackawanna & Western R. R. has recently commenced the construction of several new piers for handling freight traffic at its Hoboken terminal. The railroad company owns a frontage of 2,550 ft. along the New Jersey shore of the Hudson River opposite the lower end of New York City, and controls an area of about that width which extends back from the river for ½ to ¾ mile. This area has been developed with freight and passenger yards and terminal piers and warehouses as the traffic required, more or less without any definite general plan. The north end of the area is occupied by the passenger terminal and the yards connected with it. The design of a new passenger terminal station and some of the interesting methods of over-water work that are being followed in its construction were described in The Engineering Record for April 29, 1905, and Nov. 11, 1905, respectively. A complete new trackage arrangement for this station has also been developed and is being carried out as rapidly as possible. When these improvements have been completed the facilities will be ample to handle the passenger traffic of the road, which amounts to more than 225 trains a day at the present.



Present and Proposed Arrangement of Freight Terminal Piers and Slips of the Lackawanna R. R. at Hoboken N. J.

The old freight yard connected with the terminal piers and warehouses was laid out for storage and classification as well as for the distribution of traffic to the different piers. The freight traffic of the Lackawanna has increased so materially in recent years that it became necessary to build a large storage and classification yard at Secaucus, about 4 miles inland from the terminal, and handle only the distribution, loading and unloading of cars in the yard at the terminal. Even with this new arrangement congestion was not fully relieved and the complete reconstruction of the old freight yard and the piers and warehouses connected with it was undertaken. A part of this work has already been carried out, but a large and more interesting portion, which remains to be completed, has just been put under construction.

The first two slips south of the passenger terminal serve open piers of more recent construction and are used in handling various classes of bulky freight, such as lumber and machinery. Between the south one of these two piers, Pier No. 3 in the new arrangement, and Pier No. 4 is a ship canal, 3,270 ft. long, 120 ft. wide for 950 ft. from its outer end and 100 ft. wide for the remainder of its length. This canal is also used in handling boats carrying bulky freight and is served by tracks on each side.

On the south side at the outer end of the canal is a 190x1,330-ft. pir covered by two sheds, each 66x1,280 ft. One shed is on each side of the pier, and the two are served by three tracks between them. Both sheds are of heavy, slow-burning timber construction, with wire glass skylights and complete sprinkler system for fire protection. The south shed is divided in four parts by three transverse concrete fire walls built up from the low-water line to above the roof line. The other shed has one large room. These sheds are built to handle more perishable freight between the cars and ships and for the storage of this class of traffic. They have been completed within the last year and are a part of the new terminal arrangement.

The next pier, old Pier No. 7, is 30x1,070 ft. in plan and will be removed eventually. At present a low trestle carrying two tracks is erected on it and grain traffic is handled by gravity between the cars on the tracks and the boats in the slips. Another old narrow pier carrying a trestle and tracks which formerly stood close to this one was destroyed by a fire in May, 1904, and was not rebuilt. This same fire also completely burned over the next four piers to the south.

The first of these piers, new Pier No. 6, carries two McMyler coal-car dumping machines and the tracks which serve them. The arrangement of the dumpers and the tracks on this pier were fully described in The Engineering Record for Dec. 9, 1905. The two machines have a combined normal capacity of dumping 12,000 tons of coal every 10 hr. from the cars to coal boats in the slips. They are supplied with cars from a large storage yard for the loaded and light cars used in the coal traffic. This yard is a part of the new freight terminal arrangement and has a capacity of 600 cars.

The first pier beyond the one carrying the car dumpers is 46x1,264 ft. in plan. A high timber-bent trestle with three tracks has just been erected on the site of the old pier destroyed by fire, and a portion of the coal traffic is at present handled by gravity on it. This leaves a slip with a minimum width of 175 ft. between it and the car-dumper pier. The removal of the 30x1,070-ft. pier to the north of the latter will leave a slip with a minimum width of 260 ft. on that side of the car-dumper pier. The large number of coal boats, however, that have to be laid up in these two slips pending the arrival of the coal intended for them, require at least this amount of water area.

The remainder of the piers and slips along the water front to the south are to be completely reconstructed. The limited water front had to be developed to the fullest possible extent in order to accommodate the traffic that is tributary to the

Hoboken terminal. The railroad company owns 170 water craft of various types, varying from 80 to 2,000 tons capacity, and if all of these craft were at the home port at one time they could just barely be docked in the present slips. The passenger terminal to the north and the necessary arrangement of the freight piers between it and the south line of the slip on the south side of the car-dumper pier precluded any more complete development of the water front north of that line. A frontage of 750 ft. along the bulkhead line is thus all that is available for future development. As this frontage is extremely valuable and provision had to be made to handle a very heavy traffic which is rapidly increasing it was essential that the greatest possible length of pier frontage should be provided. The only track yard necessary in the rear of this part of the terminal is that sufficient to supply the latter with cars at all times, as the storage and classification of traffic can be handled in the new yard at Secaucus. The number of piers was thus limited from the shore end by the capacity of the distribution yard only, and as this could be made much greater than that required by any pier arrangement that could be obtained, the most complete development of the water front was practicable and desirable.

A ship canal 2,700 ft. long will be built in along the south line of the railroad company's property, from the pierhead line, and four diagonal slips built from the canal on the north side, as shown in the accompanying plan, for the new terminal arrangement. The canal and slips will have a minimum depth of 30 ft. at low water. The former will be 175 ft. wide for 1,200 ft. of its length from the outer end and 145 ft. wide in the remainder, the reduction in width being made on the south side to provide space for a bulkhead. The slips will make an angle of 30 deg. with the canal and will be uniformly 112 ft. wide and 600 ft. long. The end of the canal will also turn at an angle of 30 deg. to the main part of it so that five piers will be provided with water on both sides.

Between the inner ends of the slips and the north line of new Pier No. 7 that is to replace old Pier No. 10 is a space 280 ft. wide. That pier will occupy 46 ft. of this width and will have open water on one side only. The remainder of the space will be filled in out to the exterior line for solid fill; outside of that line it will be floored over by a special low-water construction. This construction is similar to that employed in a portion of the new passenger terminal yard. It consists of a heavy, tight timber floor laid on caps on piles cut off at low tide, with a concrete retaining wall, also built on the pile caps, around the sides of the floor. The space included in the walls will be filled with cinders or other material and the tracks laid on this shallow fill. This construction offers no obstruction to the flow of the tide and makes a fireproof footing for the superstructure.

At the outer end of the floored-over area, between the new Pier No. 7 and the outer one of the diagonal piers, now Pier No. 8, six transfer bridges will be built for car floats. The space available for these bridges was so narrow that the latter have been arranged in a slightly fan-shaped position, which is accomplished without interfering with the operation of Pier No. 8. The tracks serving the bridges and the diagonal piers will be laid on the floored-over and filled-in area between the ends of the latter and new Pier No. 7. A distributing yard, with a capacity of 1,000 cars, exclusive of the tracks on the piers and three open tracks, is to be built in connection with the distributing tracks, and will be entirely separate from the coal handling and other yards to the north.

The outer one of the five diagonal piers is to be 64 ft. wide and will carry three tracks with an outside platform on each side. Produce and fruit traffic bound in both directions will be handled on this pier. The next pier is to be 100x600 ft. in plan, and will carry a 60x580-ft. one-story heavy timber shed covered with corrugated iron. Westbound traffic will be handled in this shed, which will be served by two tracks along the pier on one side. The next pier will be 120x600 ft. in plan and will carry an 80x580-ft. shed with two tracks on one side. The following pier will be 120x600 ft. will carry an 80x580-ft. warehouse, three stories high. The last pier will be 130x600 ft. and will also carry a three-story warehouse, 90x580 ft. in plan. It is also the intention to build a grain transfer elevator on the south side of the bend in the canal. A single track will then be carried on the same side to the end of the 145-ft. wide portion.

The new arrangement of piers and slips increases the length of docks and bulkheads of the terminal 3,000 ft., or 11 per cent.; the water area is increased 270,000 sq. ft., or 16.1 per cent., at the same time. When the improvements on which work has been started are completed and additional facilities for handling traffic between the Secaucus yard and the Hoboken terminal are carried out the freight handling arrangement will be capable of providing for traffic for several yeas.

The plans for the work that has been done and that is under way in the reconstruction of the piers and slips have been made under the direction of Mr. L. Bush, chief engineer of the Delaware, Lackawanna & Western R. R., by Mr. Geo. T. Hand, assistant engineer. The construction work is carried on under the supervision of Mr. Bush and the immediate direction of Mr. J. E. Snell, superintendent of buildings and docks.

Book Notes.

For a quarter of a century Kohlrausch's "Lehrbuch der Praktischen Physik" has been one of the standard text-books of this science. While it is an elementary schoolbook, aiming simply to present the important physical principles in an orderly sequence, it is a really scholarly book. It is not descriptive, but scientific. Its illustrations are not cuts borrowed from manufacturers of apparatus and machinery, but are diagrams prepared for the purpose of explaining the text. It does not aim to furnish the basic facts of physics in sugar-coated form, so as to be absorbed with the minimum of mental effort and as readily forgotten, but it is a book that must be really studied, and one that demands elucidation in the classroom by the instructor. It will be a useful book of reference to those who can read German readily, for it presents the elements of the subject in remarkably compact form. (Berlin, B. G. Teubner, 9 marks.)

A highly instructive report has been written by Mr. Charles F. Pidgin, chief of the Massachusetts Bureau of Statistics of Labor, entitled "Industrial Opportunities Not Yet Utilized" in that commonwealth. It has been felt for some time that there were many industrial opportunities which would be of interest could some account of them be secured, and this report gives the result of inquiries made of the Boards of Selectmen of the 321 towns in the State. Replies were obtained from 231 towns, giving information concerning matters which a prospective builder of a new industrial plant wishes to know. The information is presented in such a form as to be readily consulted. The resources of the towns are described briefly, and then tabulated in various ways. In the first table the towns are classified according to their available land, number of railway stations in town, their distance from the unoccupied land available for manufacturing, and the amount of unappropriated water-power. In a second table the information concerning water supply, gas and electric service and electric railways is summarized; in a third, the raw materials and natural products of the towns are stated, and in others the number and character of the idle factories and the class of industries desired in the towns are stated in such form as to be readily reviewed. It is interesting to observe that 48 towns wish for boot and shoe factories, 44 for canneries, 24 for woolen mills, 20 for hotels and 19 for wooden-ware shops. It would be interesting to know whether these industries are desired because of the now idle help trained in them or because there is a legitimate demand for them.

Volume V of the "Proceedings" of the American Society for Testing Materials gives a report of the eighth annual meeting held at Atlantic City last summer. It is particularly valuable as containing standard specifications adopted by the Society for structural steel for bridges, steel axles, steel forgings, steel castings, cast-iron car wheels and gray iron castings, together with the reports of committees entrusted with the preparation of specifications for other materials. Up to the present time the Society has adopted eighteen standard specifications, and the widespread use of these is conclusive proof of the value of the work of the association. So much has been printed in this journal concerning the process of preparing these specifications that it is unnecessary to say more in this place than that they are unquestionably the fairest general specifications drawn up in the country. They do not cover special cases, but only ordinary requirements; supplies bought under them will probably be of lower cost and more uniformly good quality than those purchased under specifications containing unusual requirements. In addition to the reports of committees and specifications already mentioned, the volume contains a number of interesting papers on the properties of materials, methods of testing and apparatus for the purpose. These volumes are sold at $5 each to the public and $3 to members, and are unquestionably the most important engineering publications issued by any American engineering organization. They can be obtained from the secretary, Prof. Edgar Marburg, University of Pennsylvania, Philadelphia.

Those readers who are interested in mathematics will be glad to know that a thoroughly scholarly work, "Lectures on the Calculus of Variations," by Prof. Oskar Bolza, has recently been added to the very small number of really important American mathematical books. We have produced excellent textbooks, but only a few treatises. This is a representative of the latter class, and probably the only one in any language in which the latest investigations concerning the theory of the calculus of variations is conpletely set forth. The conditions of Euler, Legendre and Jacobi, on which the older works on the subject rest, are here carried forward by a discussion of the fourth condition due to Weierstrass and his school. Even an explanation of the principles of the subject would be out of place here, but the appearance of a really authoritative work on it deserves mention, particularly as the field in which mathematics can help engineering is widening so rapidly that it is difficult to say whether the engineer or the physicist will reap the first important results from each new mathematical victory. (Chicago, University of Chicago Press.)

Of the many contributions to the literature of the Panama canal there have been none of greater interest than the lecture by Mr. Philippe Bunau-Varilla before the National Geographic Society, at Washington, recently. As there may be some misunderstanding concerning this gentleman's interest in the undertaking, it might be stated here that he has no desire, it is understood, to have any further connection with the great enterprise, either as contractor or engineer; having retired from active work, he gives a portion of his time to making public opinions concerning the proper prosecution of the work of construction formed during a longer and more intimate connection with canal building on the Isthmus than any engineer now living in the country. His project is the construction of a lock canal with a summit level of 130 ft., which can be opened after four years of active work, he estimates. This canal will accommodate the initial traffic, but must be gradually widened and deepened down to the sea level, so that the commerce of the future can be directed through the Isthmus along what he terms the Straits of Panama. This enlargement he considers a much easier task than the construction of a large low-level canal at the outset, because the excavation and removal of the spoil could be done by floating equipment. The project also includes the construction of a large lake by damming the Chagres near the high-level reach of the lock canal first constructed. This lake is to furnish power for the operation of the plant, will serve as a regulating basin for the discharge of the Chagres River, and as a dumping ground for the spoil obtained from the excavation. In the construction of these works it is proposed to utilize an auxiliary canal rather than railways, because the conditions are such, in the author's opinion, that water transportation of materials will be far less expensive than handling them by railway. The lecture has been published with numerous interesting illustrations in a pamphlet of 35 pages, copies of which can doubtless be obtained from the author, whose address is the Waldorf-Astoria, New York.

There have been few railway undertakings in this country more interesting than the construction of the Cincinnati Southern Ry. by the city of Cincinnati, the leading example of municipal trading in the United States. There have been other roads constructed by municipal authorities, but they were all short, like the East Brookfield branch of the Boston & Albany R. R., while the Cincinnati line was a complete interstate railway undertaking. The history of the initial steps is well told in "Founding of the Cincinnati Southern Railway," by Mr. E. A. Ferguson, "the man whose ingenuity and knowledge of the law drew the first act; who, as trustee, thought out a plan for the construction of the road which was finally carried out almost to the letter; whose faith never wavered, and who cheered in times of despondency; whose indomitable courage withstood attacks from fellow trustees, from newspapers, from the wealthiest men in the city; whose steadfast conviction as to policy sustained him through criticism and objection; whose fertility of resource, capacity to meet obstacles and overcome them, whether interposed by general assemblies or chamber of commerce, never failed him." The story he has told is one of deep interest, not only as an account of an engineering undertaking of considerable difficulty, but also as a record of a unique instance of municipal endeavor. Cincinnati owed its original importance to river traffic, and with the development of the northern part of the State its importance was threatened by the railways which it was early foreseen would connect New York and Philadelphia with Chicago by way of the Lake cities. In fact, eighty years ago, soon after the locomotive was put in service in the United States, when Cincinnati was the commercial city of the West as it was then understood, there was considerable talk of constructing a road to connect the city with the South. Nothing was done, however, and thirty years later the pestige of the place began to slip away. It was asserted by the conservative citizens that if a road was really needed private capital would build it, while those who were in touch with the feeling in railway circles of that time were convinced that the more profitable fields for railway work farther west would leave Cincinnati isolated. As the trade of the city kept dropping from the relative position it should hold, it was finally determined to undertake the building of the road. The enabling act was drawn in 1869 by Mr. Ferguson; there was a long struggle in securing rights from the legislatures of three states for crossing their territory, and from Congress for bridging the Ohio River, and the constitutionality of the enabling act had to be upheld in the Ohio courts, so that cars did not run into Chattanooga until 1880. At the present time there seems to be little reason for questioning the importance of the undertaking, and the record of its early days, as given in this interesting volume, deserves reading. (Robert Clark Co., Cincinnati.)

KRANE. Ihr allgemeiner Aufbau nebst maschineller Ausrustung, Eigenschaften ihrer Betriebsmittel, einschlägige Maschinenelemente und Trägerkonstruktionen. By Anton Böttcher, assisted by G. Frasch. Munich, R. Oldenbourg; cloth, one volume text and one volume plates, 25 marks.

The purpose of the author of this important work is to give a general view of the whole field of crane construction, which has been greatly developed in the last ten years. In the preparation of the text two points have been kept constantly in mind, the first being to present only really useful information, and the second to furnish the data of direct value in the designing room in such shape that with the assistance of the excellent index they are immediately available. The author is particularly qualified to write on the subject because, after long experience in the design of cranes, he was given the problem of redesigning such apparatus in the works of the Vulcan Company at Stettin, at the time that this great establishment was rearranged for electrical operation. The reconstruction of the cranes in these works, together with the construction of others for the extensions of the plant, made it necessary to conduct very complete investigations of all kinds of details as well as of general designs, which the owners of the works have allowed the author to use in the preparation of this book. The data include not only design but also construction, erection, testing and maintenance. To secure further material for the book the author visited the leading German ports and industrial centers in order to study special appliances with which he was not personally familiar.

The first section of the text is devoted to the principles of statics, dynamics and elasticity which are employed by the crane designer. The second section is a general description of the classes of cranes, traveling, locomotive, jib, post, gantry, shear-leg and the rest, and is mainly interesting as indicating the present condition of this class of equipment in Germany, which will be found to differ materially from that of American practice, as certain types which have been developed here are apparently not regarded with so much favor in Germany, and vice versa.

The third chapter is one of the most important in the book. In it the different systems of operating cranes are discussed in detail and many details of design are given which will probably prove of much value to the drafting room in which such equipment is planned. The author takes up in succession hand operation, rope and shaft operation, steam operation, hydraulic operation and electric operation. It will be noticed that pneumatic cranes, such as are used for small loads in many American shops, are not considered in this section of the book, indicating one of the points of difference between German and American practice. Naturally enough the electric method of operation receives most attention, and engineers who have been following the development of American crane motors will be surprised to learn the lack of accord between what may be called the standard practice of the present time in the two countries. The fourth section of the book is equally important, for in it the author describes the detail design of the important mechanical elements of German cranes. This section will appeal more to the maker than the user of cranes, although there is a portion on brakes and similar devices which is of considerable general interest. The remainder of the work relates to crane girders, and descriptions of the methods of designing the details of eleven different types of cranes. An appendix contains tables of the properties of structural steel, a bibliography of books and papers consulted by the author, and extracts from official rules and specifications of interest in connection with the subject.

THE CATHEDRAL BUILDERS IN ENGLAND. By Edward S. Prior. Portfolio Artistic Monographs Series. New York, E. P. Dutton & Co.

There is no kind of construction that has been so intimately associated with the mental characteristics of people as ecclesiastical architecture, but it is only within a comparatively few years that the relation between the temperament of an age and its cathedrals has received much attention. The author of this book is one of the few English authorities who have laid proper stress on the subject, as those who have read his "History of Gothic Art in England" will recall. In his latest book he has given a sane and interesting account of the rise and development of architecture in his native country, in which some of the old myths are handled without any respect for their venerable age. There are so many interesting things about the structural features of these old Gothic churches that we can well spare the traditions concerning secret organizations of masons who possessed carefully hidden rules of design. Mr. Prior disposes of such tales of a close organization of builders with the assertion that if it existed it "must have had a supernatural power of hiding its tracks, for in all our accounts and records are no references which can be twisted into a consciousness of a freemason guild. Instead of indicating a central body of masoncraft to which ecclesiastics applied for the building of their churches, they mention artisans coming haphazardly together, and their organization for the special work, as at Canterbury; or in the case of continuous building in one of our large cathedrals, we have the establishment of a cathedral bureau, such as at York, which has, indeed, practically continued to our own day."

The text is divided into chapters devoted to the several periods of cathedral architecture, according to the modern classification which makes their number seven between the Conquest and Reformation alone. This division is a little startling to those who have not kept in touch with architectural criticism, but it is far more logical than the old subdivision into a few periods. This new subdivision is based on a critical study of the buildings from more than one point of view, and it takes into account that such a national catastrophe as the Black Death in the middle of the fourteenth century, to mention a single event, made a break in art as well as in other aspects of the life of that age. In discussing the characteristics of each period the author points out how they were influenced by the state of handicrafts and of public conditions in the vicinity of the places where the work was going on, as well as by social causes. A good idea of the author's style and method of presenting a subject may be shown by the following quotation from his explanation of the character of the builders who introduced the flamboyant style: "They seem to me to present themselves in the guise of splendid revelers making a day of carnival for which all the hard facts of life are put away out of sight. It is all brilliancy and merriment in their luxurious spendthrift art, bred of the joy and pride of a class of nobles."

A feature of the book that is most welcome to those who desire to know what the great masterpieces of Gothic art looked like in the time of their builders, or before they were "restored" out of semblance to their original form, is the series of illustrations. These are not the misleading photographs commonly employed, but reproductions of drawings made by men of former days, able to interpret what they saw in a satisfactory manner. To the reader who does not know the brilliant coloring of the old cathedrals, four well-executed reproductions of illuminated drawings of the fourteenth and fifteenth centuries, showing the splendid coloring of the churches of that time, will be a great surprise.

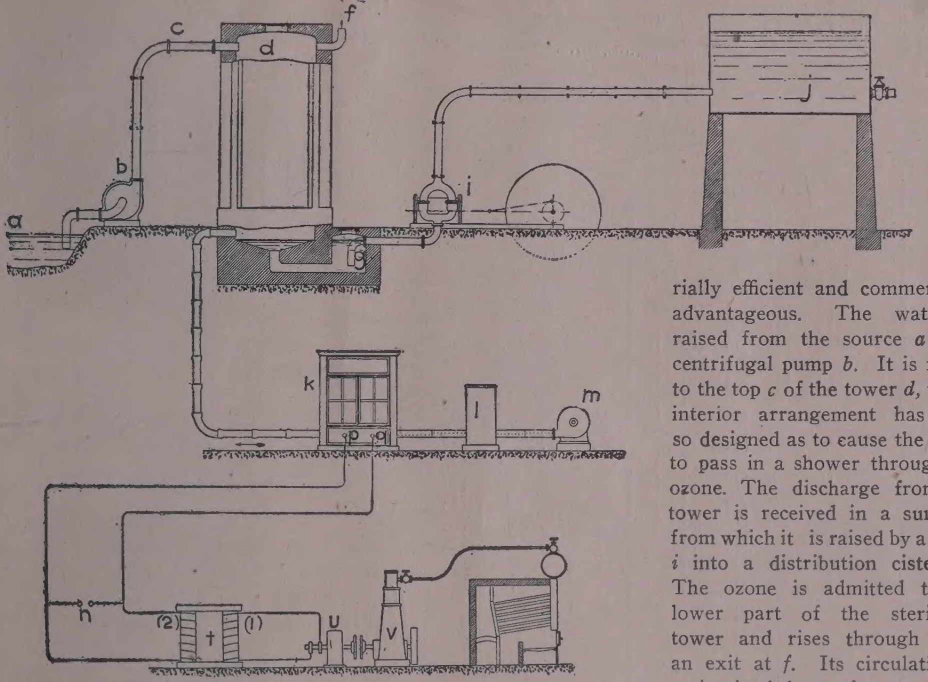
EARTH HANDLING is done very economically on a contract held by Mr. H. W. Hawley of Seattle. The wagons are loaded by a steam shovel and hauled to a platform over the upper end of a double-track narrow-gauge tramway having sufficient grade to allow the loaded 4-yd. car to haul up the unloaded car by a rope passing around a sheave under the platform. The cars are controlled by a friction rope around this sheave. The wagons dump their contents into one of the cars, which is then run down the tramway to the face of a bluff 600 ft. distant. Here the car is automatically dumped into a chute leading to a railroad cut on a siding at the foot of the bluff. This outfit saves nine-tenths of the cost of hauling in carts from the shovel to the railroad.

Letters to the Editor.

THE STERILIZATION OF WATER BY OZONE.

SIR: In The Engineering Record of Sept. 2, 1905, you gave a brief review of the status of sterilizing water by ozone. In continuation of those statements it might be of interest to your readers to learn that its use was first suggested by Professor Ohlmueller, but it is only recently that Messrs. Marmier & Abraham perfected a practical and commercial system. Two obstacles could not be surmounted by previous inventors. The first was the difficulty of obtaining a concentration of the ozone and the second was the necessity of producing a mixture of the ozone with the water of such an intimate nature as to assure the destruction of all the germs.

The principle of the methods of the Parisian inventors is to pass the water to be sterilized through a vertical cylinder filled with concentrated ozone, and it is only in this apparatus that it has been possible to produce the thorough mingling of the gas and water in a manner bacterially efficient and commercially advantageous. The water is raised from the source *a* by a centrifugal pump *b*. It is forced to the top *c* of the tower *d*, whose interior arrangement has been so designed as to cause the water to pass in a shower through the ozone. The discharge from the tower is received in a sump *g*, from which it is raised by a pump *i* into a distribution cistern *j*. The ozone is admitted to the lower part of the sterilizing tower and rises through it to an exit at *f*. Its circulation is maintained by a fan *m*. This draws atmospheric air through a dryer *l* into the ozone generator *k*, and finally into the column *d*. The dryer is merely a cylinder containing concentrated sulphuric acid, which absorbs the aqueous vapor in the air. The ozone generator consists of two sheet-metal disks D_1 and D_2 suspended so that their faces are parallel. Two glass plates *PP* are placed against the disks, being separated by a space forming the gap for the electric discharge. The disks D_1 D_2 are enclosed in a hermetically sealed box. The air enters at *a*, passes through the discharge gap as indicated by the arrows, and leaves the chamber at *o*, to be utilized later in the sterilizing tower. The disks are hollow, and are cooled by circulating water in them, so as to prevent any serious rise of temperature from the transformation of electric energy. The current is furnished by a transformer *t* which has its primary (1) connected to an alternator *u*, driven by a steam engine *v*. The secondary connection (2) furnishes current to the apparatus at a tension of about 40,000 volts. At *n* there is a shunt on the high tension wires, provided with a deflagrator having two spheres between which an electric spark is passed. A jet of compressed air or steam is blown on this spark continuously. It may be remarked that the idea of cooling the electrodes is old, but Messrs. Marmier and Abraham were the first to show how a current of water could be electrically insulated in such a practical manner as to permit cooling by continuous circulation.



General Arrangement of a Marmier-Abraham Ozone Plant.

The first of the two difficulties with ozone apparatus, mentioned above, the high concentration of the ozone, is attained by the continuous cooling of the disks in conjunction with the use of the deflagrator. The cooling permits the use of intense electric discharges which alone can give concentrated ozone; and, by means of the deflagrator, it has been possible to produce these discharges economically.

The second difficulty, the intimate mingling of the ozone and water, is due to the fact that ozone is practically insoluble in water. This insolubility is an indispensable guaranty and gives absolute assurance in every case that the water delivered for drinking purposes does not contain, as a result of its treatment, any appreciable trace of the sterilizing agent. The intimate contact of the liquid to be sterilized and the gas accomplishing this end is produced in the tower already mentioned.

Among the installations which show the value of this process may be mentioned the plant at Emmerin (Lille) and that at the Boleo mines in Mexico. The two plants are identical in principle. When it is possible to obtain the alternating current from a central station, the general process is modified and simplified. This is the case at the Boleo plant. The primary current is furnished to the transformer from one of the phases of a three-phase 5,000-volt vircuit. Regulation is afforded by a self-induction coil, and the blower is driven by a three-phase motor. One of the diagrams shows the arrangement of the apparatus to measure concentration of the ozone. This concentration is controlled by the operation of the ozone generator and that of the tower. The ozone is drawn through a flask filled with iodide of potassium, which fixes the ozone, and through a gas meter which determines its volume.

The installation at Emmerin is an example of a typical self-contained plant. The current is furnished by an alternator driven by a steam plant. The transformer, ozone generator and deflagrator are contained in an adjoining building. The ozone is drawn through the apparatus by a Koerting aspirator at the top of the tower, instead of by a blower. The city authorities of Lille appointed a technical commission to investigate the operation of the plant and the results obtained at it. Their tests lasted more than two months and their conclusions were as follows:

"The process is of incontestible efficiency, which is greater than that of all other known processes of sterilization which can be employed with large volumes of water. The very simple arrangement of the apparatus, its durability, the uniformity of its output and the regularity of its operation furnish all those guaranties that it is right to demand in really commercial appliances. All the pathogenic or saprophytic bacteria in the raw waters investigated have been entirely destroyed by their passage through the ozonizing column. Only the inoffensive B. subtilis resisted the treatment. About one germ of this species remained in each 15 c. c. of water treated with a concentration of the ozone equal to 0.006 gr. per liter of air. With a concentration of 0.009 gr., the number of these germs which could be revived in bouillon fell to one per 25 c. c. of water treated. The ozone treatment of the water does not introduce any foreign substance into the water prejudicial to the health of those using it. On the contrary, by not increasing the amount of nitrates and by appreciably reducing the amount of organic matter, the treated waters are less subject to subsequent pollution and, consequently, are much less subject to change. Finally, ozone, being only a special molecular form of oxygen, the use of this substance presents the advantage of energetically aerating the water and of making it more healthful and palatable, without changing its mineral elements."

Yours truly, A. Steens.
Paris, Dec. 16.

Thawing Frozen Water Pipes by Electricity.

Sir: The superiority of the electric current as a thermal agent being generally recognized and its convenience and effectiveness having led to its utilization in the thawing of water pipes in many instances in the past few years, this subject has become of great interest to all water works departments of our Northern cities. During the winter of 1903 and 1904 we applied the electric current to this use with good results. We used the local power and lighting current of 2,200 and 1,100 volts primary, passed through transformers of 110-volt, 25-kw. capacity. Transformers were mounted on platform sleighs and drawn from place to place, as is the usual practice in such cases. We found this outfit to do the work quickly and with good results, but, as is the case in nearly all cities, we were unable to thaw out a good many service pipes on account of there being no primary wires in the immediate locality to take the current from. The following year we had built by the General Electric Co., at their works in Schenectady, an outfit for this work of which a description follows.

The outfit assembled consists of an alternating-current generator direct-connected to a gasoline engine, the whole mounted on a steel frame made of 12-in. I-beams and placed on a pair of bob sleighs. The generator is self-exciting, and while its rating is 15 kw. it has been safely operated out of doors for four or five hours at an output of 22 kw. It is of the revolving-field type and is provided with a terminal board by which the armature coils can be placed in series, series-multiple or multiple, thus giving voltages of 110, 55, 27½ and 15 volts respectively. A rheostat provides intermediate voltages. The gasoline engine driving the generator is a two-cylinder Westinghouse (Schenectady) engine of 24 h.-p. By operating this engine at a speed of 350 r.p.m. it will develop 30 h.-p. continuously or 36 h.-p. for a half-hour run.

For delivery of the current to the frozen pipe a rubber-covered and braided cable, of 450/25 wires is used. The entire outfit, with cooling tank filled, weighs about 7,800 lb. and is easily drawn about by one team. This apparatus was delivered to us last winter and was used with excellent results. On one occasion we thawed a 6-in. water pipe frozen for a distance of about 100 ft. in two hours and small service pipes were opened in from two to ten minutes after the switch had been closed. With this machine we are now able to thaw a frozen water pipe located anywhere in the city, which is a great advance over using the commercial current through transformers.

No doubt the apparatus can be built of smaller capacity and of lighter weight for the thawing of small house pipes, but as built for us it is guaranteed by the General Electric Co. to be of sufficient capacity to thaw out any pipe up to 16 in. in diameter. As this is the only machine of its kind known to have been built, I think possibly the foregoing description might be of interest.

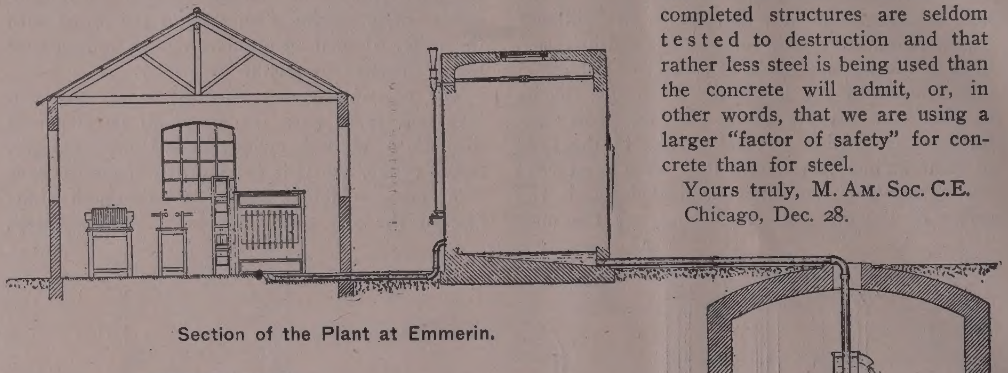
Yours truly, Alexander Orr.
Gloversville, N. Y.

The Theory of Reinforced Concrete.

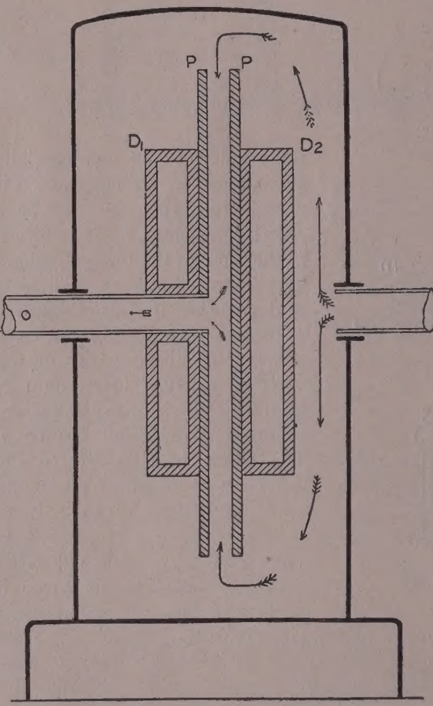
Sir: The communication from Mr. Goldenberg in The Engineering Record of Dec. 23 should not be allowed to pass without comment. Laboratory investigations of reinforced concrete beams have been mainly carried on to furnish information concerning the phenomena that occur when such composite members are loaded. The nature of the phenomena is easily studied when the composite structure of the beams is simple and the tests are generally made most conveniently by concentrated loading. The test conditions are not those to be met in buildings and bridges, but they are adequate for the purposes of investigation. Experimenters certainly never resorted to laboratory tests with concentrated loading on isolated beams to demonstrate "that the ultimate strength of a beam is reached when it is so loaded that the steel is stressed to its elastic limit." The facts are that the results of tests, interpreted in a prudent way as befits a profession whose errors should always be on the side of safety, show that it is not wise to stress steel beyond its elastic limit, whether incased in concrete or not. As a matter of fact, it is evident that the term "factor of safety" is what Mr. Goldenberg is criticising, which is not at all surprising in view of the steady succession of needless complications which that unfortunately designated coefficient has received since it was introduced. In steelwork it really means one thing, in masonry another and in reinforced concrete still another, and in each of these classes of design it is a coefficient of ignorance, to allow for uncertainties in theory, materials and workmanship. These practical obstacles to the direct application of pure theory are known to exist, and the judgment of the engineer is shown by the skill with which he estimates their true importance and thus keeps the cost of his structures down to a minimum.

The illustrations accompanying the article suggest very strongly why the beams Mr. Goldenberg has tested in practice do not agree with the laboratory tests which he criticises. If, in either of the cases illustrated, the beam deflects an appreciable amount, there is little opportunity of determining how much of the load of pig iron will be supported by the beam acting as such. There appears to be no precaution against arching in the load, and very few engineers will agree that "the load of 91,500 lb. shown is practically uniform." It is not safe to estimate the actual stress in the steel reinforcement from loading of this character, although the test does show the total dead load carried by the structure as a whole, independent of its beam action. It is important to distinguish between the two loads. If "in actual tests on complete structures, a failure in compression is almost unknown," the explanation is to be found in the fact that completed structures are seldom tested to destruction and that rather less steel is being used than the concrete will admit, or, in other words, that we are using a larger "factor of safety" for concrete than for steel.

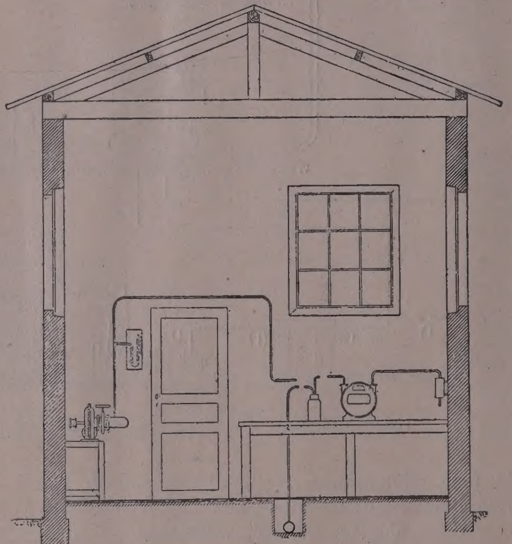
Yours truly, M. Am. Soc. C.E.
Chicago, Dec. 28.



Section of the Plant at Emmerin.



The Ozone Generators.



Installation at Boleo.

Unusual Magnetic Observations have been made by Mr. Thomas Russell, U. S. Assistant Engineer, in the Tamarack copper mine, 4,760 ft. below the ground in a level about 1,200 ft. from the shaft. The diurnal range of declination in the mine, the difference between the morning eastern and afternoon western elongation, was 14 minutes of arc which is about the same as observed at the surface of the earth in that vicinity. The times of elongation were also about the same as at the surface of the earth. The dip was 27 minutes less in mine than at the corresponding point above it on the surface of the earth. The total magnetic intensity in mine was 0.6227 of a dyne as compared with 0.6070 at the surface of earth just above it, or about a fortieth part greater in the mine than above at the ground. It is interesting to note the decrease in dip and increase in intensity in going down into the earth. As far as known, no results of observations of dip and intensity made in deep mines have before been published. The work was done as part of the Great Lakes Survey.